POWER

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Keep Going

THE power-plant of today is a different affair from the modern plant of twenty-five years ago. And the man who takes care of it is a different kind of man.

What will the power plants of 1950 be like?

What will the men who design and construct and operate them have to know?

Some of the plants of a quarter century back have held their own—and that is all.

They are running along on the Nineteenth Century plane in heedless unconcern of the improvements that have been made and of present possibilities.

They will wear themselves out and give place to new and efficient installations or "street current" or go into limbo with their dying industries, without ever having got any better.

And too often the men who run them will go the same way.

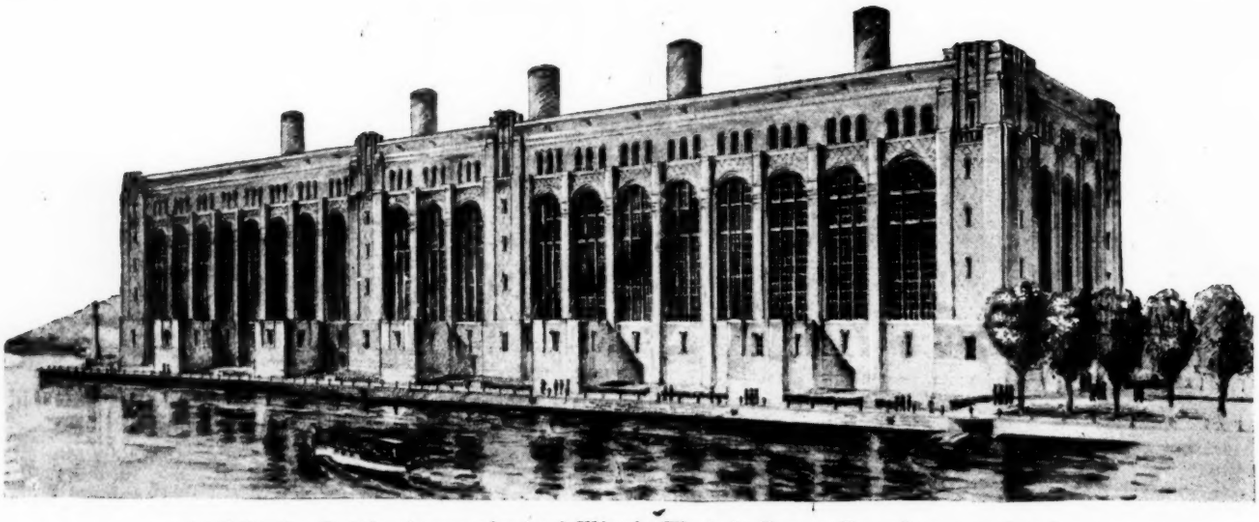
They were new and bright and up-to-date when they took charge twenty-odd years ago. They knew all that they needed to know to run that plant, and they thought they had got it all.

They derided the man who thought he had to study, vaunted the superiority of their practical knowledge—and stayed as they were.

But the art moved on, and it is the men who kept up with it that hold the big jobs today.

And it is still moving on, and the man who, with tireless discontent at his own inadequacy, keeps abreast of the movement will be the one who is called to the bigger opportunities as they develop.

F. R. Low



Architect's sketch of new plant of Illinois Electric Power Co. when completed

New Station Under Construction at Peoria, Illinois

Initial section of five-unit plant consisting of two 20,000-kw. turbo-generators, each served by two 13,920-sq.ft. boilers burning powdered coal, designed for 400-lb. pressure and 250 deg. superheat. Closed feed-water system with automatic deaëration of water; stage bleeding at four points to serve evaporator and closed heaters; house generator and its exciter on main unit shaft; U-fin type surface coolers for generators; hydraulic sluicing of ashes.

DIRECTLY across the Illinois River from the present plant of the Central Illinois Light Co., of Peoria, a new station is being erected. Planned for an ultimate capacity of 100,000 kw. in five sections, the initial installation, now under way, will have two 20,000-kw. turbo-generators, each served by two boilers fired with powdered coal and to operate at a steam pressure of 350 to 400 lb. and superheat of 250 deg. F.

Unusual difficulties were encountered before actual construction work could begin. The site was low and marshy, and that portion on which the plant is located was under some ten feet of water, requiring about 100,000 cu.yd. of fill. Secure footings could not be obtained without going to considerable depth with caissons, which are belled at the bottom and rest on clay at approximately fifty feet below the river level.

From the accompanying illustrations, some idea may be had of the external appearance and the general arrangement of the plant. The headpiece is from an architect's drawing of the ultimate plant. The design is artistic and the appearance more attractive than that of the usual power station. The exterior walls will be of dark brown brick with black rake mortar joints. The interior will be of panel salt-glazed brick of two shades of light gray or brown. The floor in the turbine room will be red, Master Builder's finish, with a black border, but in the rest of the plant will be the natural color with cement hardening.

Although the ultimate five-unit plant will be 478 ft. long, the present building is approximately 116x216 and the height 92 ft. above grade. A transverse section at one end of the plant, 21 ft. wide, will contain the office, storage rooms, laboratory and repair shop.

From the sectional elevation, Fig. 1, it will be seen that the turbine-room basement is 10 ft. below low-water level, so that all the pumps can be started without priming. The turbine-room floor is 30 ft. above the basement level and approximately 5 ft. above the highest known stage of the river. Owing to the difficulty in getting foundations, the switchhouse and reactor room were built above the turbines, so that the heights of the two main departments of the plant are practically the same. On the boiler-room side the boilers, economizers, coal bunkers and stacks are supported on steel girders.

In the generating end of the plant some interesting features are to be incorporated. The main units are rated at 25,000 kva. and are capable of carrying 23,500 kw., with maximum stage bleeding from four different points. The house generator is carried on the shaft of the main unit, and on the end of the house-generator shaft is an exciter serving the house generator only. The main generator is to be excited at 250 volts from motor-generator sets supplied from the house generator. Circulating, condensate and boiler-feed pumps are supplied from the house generators; the rest of the auxiliaries draw from the main bus through transformers. Normally, each house generator will supply the auxiliaries for its particular turbo-generator, but in case of failure of the house generator these auxiliaries may be operated from the main bus, the circuits being supplied with interlocking switches so that a change-over can be effected without dropping the load or paralleling the house generator with the main bus.

This arrangement, which is now being adopted in several new plants, has the advantage that the house generator will operate with the economy of the main unit, and separating the excitation of the house generator and the main generator, as described, eliminates the possibility of electrical disturbances on the main machine from affecting the reliability of the auxiliary power.

The only steam-driven auxiliary in the plant is one boiler-feed pump, which will be used in case of emergency. To meet normal needs there will be three motor-driven feed pumps, two of which will be operated from one house generator and the third from the house generator on the other unit, thus further insuring continuity of service of a most important boiler auxiliary.

Condensers of the two-pass type, having 1-in. tubes and 25,000 sq.ft. of surface, or 1¼ sq.ft. per kilowatt of generator rating, will serve each unit. At the entering end of each pass the tubes will be rolled into the tube sheets and the openings rounded to prevent clogging from débris.

Circulating water, which will be drawn from the river, will be supplied to each unit through a separate intake well equipped with a vertical revolving screen, as shown in Fig. 2. The low-water stage of the river is about six feet above the center line of the pumps, so that they will not require priming. The system operates as a closed siphon, so that the pumping head consists only of pipe and condenser friction. A 10x10-ft. discharge tunnel running the full length of the plant and directly under the turbine foundation serves the two units in common. It will have sufficient capacity to take care of the ultimate plant.

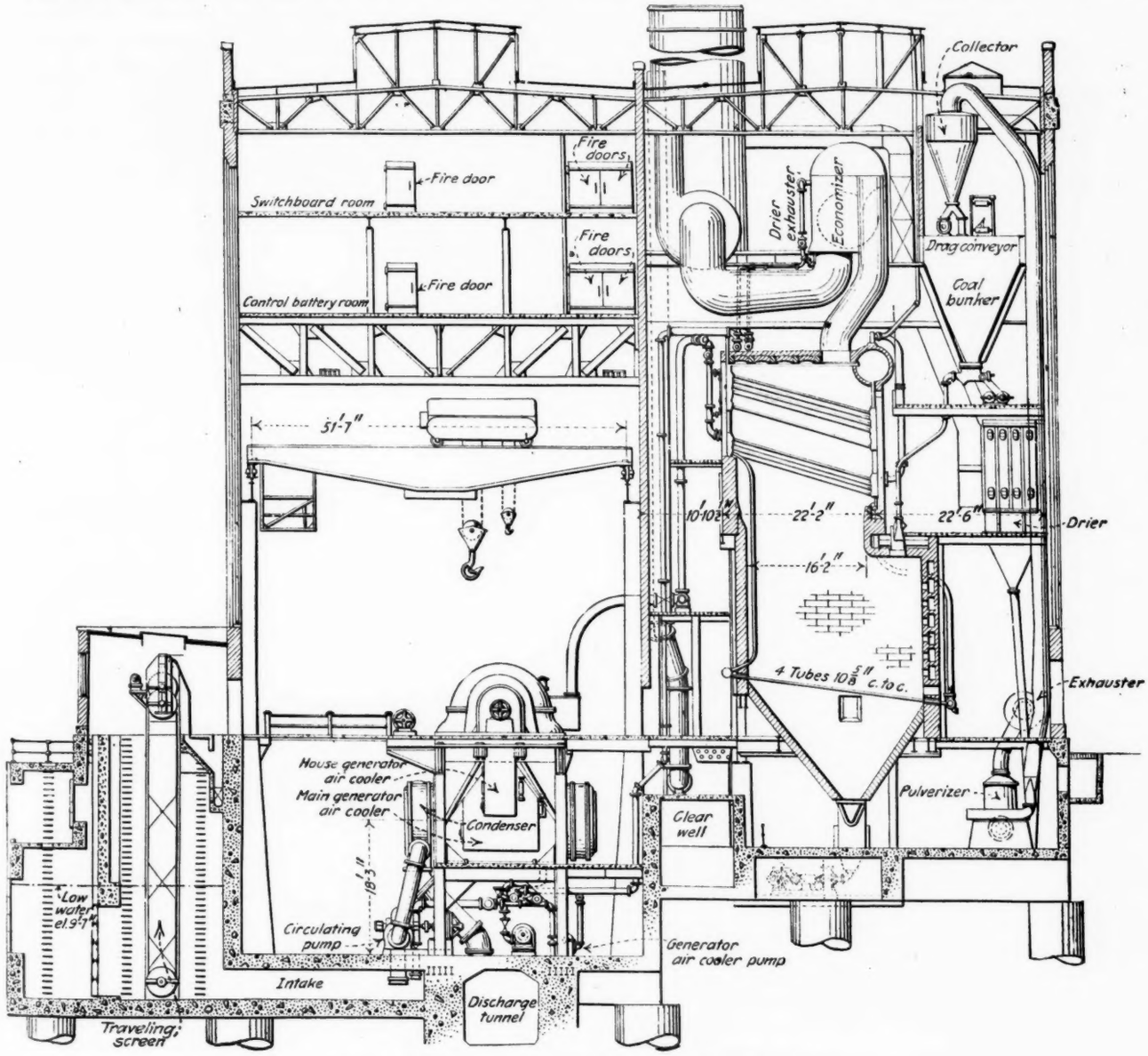


Fig. 1—Sectional elevation through power plant

Two constant-speed motor-driven circulating pumps have a capacity to supply 30,000 gal. per min. to the condenser. Variable-speed motors were considered, but under the conditions existing at the plant the saving in power did not warrant the additional expenditure that would have been necessary. During light loads or when the temperature of the circulating water is low, one pump will be sufficient to meet the requirements. All pumps serving a unit will be started at a

panel board directly alongside of the main unit on the turbine-room floor. The motor-operated valves on the circulating-water lines also will be controlled from this point.

Vacuum pumps will be of the steam-jet type with intercooler and after-condensers. The jets will operate on steam at 140 lb. pressure, taken from the supply line to the main turbine ahead of the throttle valve through a reducing valve.

Heat Balance

Reference to Fig. 2, the piping-layout diagram, will show the general arrangement of the feed-water system, including an evaporator supplying 3½ per cent makeup, two closed heaters, a clear well, surge tank and a hotwell of large size below the condenser. It will be seen that the turbine has four bleeder connections. At the most economical load the absolute bleeding pressures will be approximately as follows: No. 1 bleeder with a pressure of 147 lb. abs., will be used for cracking the evaporator coils. No. 2 bleeder at 43 lb. pressure, will supply the evaporator, which in turn discharges its vapor into the second feed-water heater. From this same bleeder line through a reducing valve steam will be taken to heat water for domestic use and for heating the building. No. 3 bleeder line, drawing steam at 14.7 lb. pressure, will supply the second feed-water heater, raising the temperature of the water to 205 deg. F., while bleeder No. 4 will supply steam at 2.3 lb. pressure to the first feed-water heater and raise the temperature of the feed water to 137 deg. F.

Condensate from the main condenser is first pumped through the intercooler and after-condenser and then through the first and second heaters in series. At times of full load when the water pumped through the inter and after-condensers is more than sufficient, a relief valve bypasses a portion of it directly to the first heater to reduce the friction loss. Upon leaving the second heater at a temperature of 205 deg. F., the feed water enters a common header forming the suction of the boiler-feed pumps. A surge tank of 4,000 gal. capacity floats on this header. This tank is large enough to take care of the normal difference in the rate of feeding the boilers and was placed at this point in the feed-water system so that the turbines and boilers need not be operated on the unit system, and still have each turbine heat its own condensate.

Raw water to the evaporators, which may be operated continuously or as the requirements demand to supply 3½ per cent make-up water, will be taken directly from the river. It contains about 12 grains of incrusting solids per gallon and, if found desirable, can be treated. Any excess of evaporated water is stored in a clear well of sufficient capacity to give several days' supply with the evaporator out of service. The condensate from the evaporator is flashed in succession through the stage heaters and with the condensation from the heaters is discharged into the large condenser hotwell, into which it is injected through perforated brass pipes, thus reheating the main turbine condensate and deaërating the water. A dam is provided in the hotwell to maintain a constant head of water. The heaters are supplied with air vents leading back to the air-pump suction, the amount of air being controlled by means of valves on the bleeder lines.

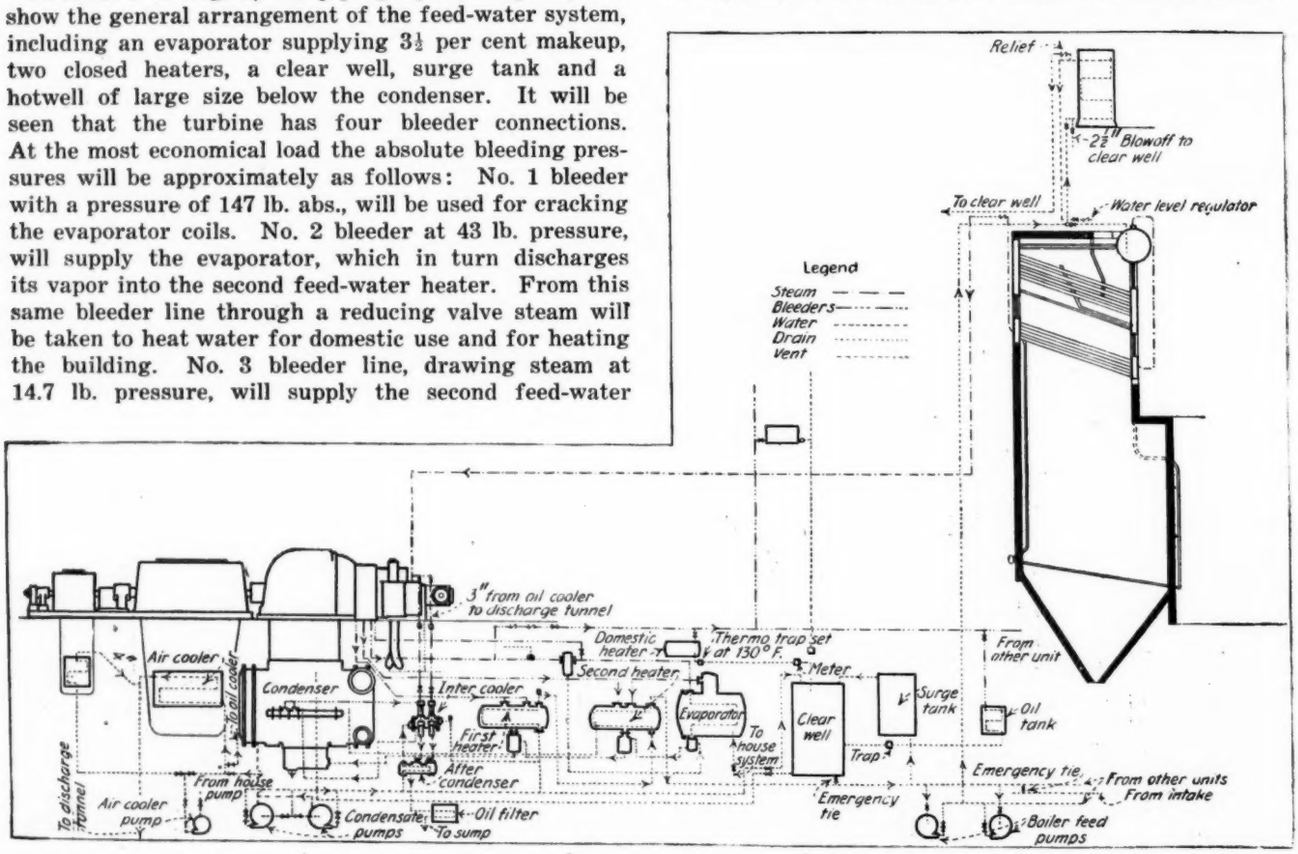


Fig. 2—Diagram showing piping-layout

Should there be a surplus of make-up water, the level in the surge tank rises and opens a float valve on the line from the condensate pumps to the clear well. In case of a deficit of make-up water from the evaporators and the water in the surge tank falls, a second float valve opens, admitting water from the clear well directly into the main condenser above the tubes. By this arrangement the temperature of the clear well is kept low and all the feed water is deaërated. In case of failure of the turbine the feed pumps can take their suction directly from the clear well or through an emergency tie line from the intake wells serving the condensers.

Features of the boiler room and the arrangement of the powdered-coal system in the same building in close proximity to the boilers are shown in the sectional ele-

vation, Fig. 1. It will be recalled that there are two boilers per unit, each containing 13,920 sq.ft. of steam-making surface, or a provision of 1.392 sq.ft. per kilowatt of generator rating. The boilers are designed for a maximum rating of 350 per cent and for a steam pressure of 400 lb. gage, although it is probable that the operating pressure will approximate 350 lb. and the superheat 250 deg. F., giving a final steam temperature in the vicinity of 685 to 700 deg. F. The boilers are of the cross-drum water-tube type with a drop bank of tubes to provide space for inter-deck superheaters. Below the superheater there will be six rows of tubes. In the four lower rows alternate tubes will be left out to form a slag screen. Additional boiler surface (1,210 sq.ft. per boiler) will be provided by a water screen at the bottom and rear of the furnace connected into the circulation.

Each boiler will have ten vertical pulverized-fuel burners. A furnace volume of 16,000 cu.ft. provides at the maximum rating of the boiler that slightly less than one pound of 10,000 B.t.u. coal will be burned per cubic foot. The flame travel is approximately 45 feet.

A single-pass, counter-current high-pressure economizer, containing 8,400 sq.ft. of surface, will serve each boiler. An induced-draft fan will discharge the gases into a 150-ft. steel brick-lined stack of 13 ft. inside diameter serving the two boilers of a unit.

Temporarily, coal will be unloaded into a pit by means of a locomotive crane, but provision has been made to

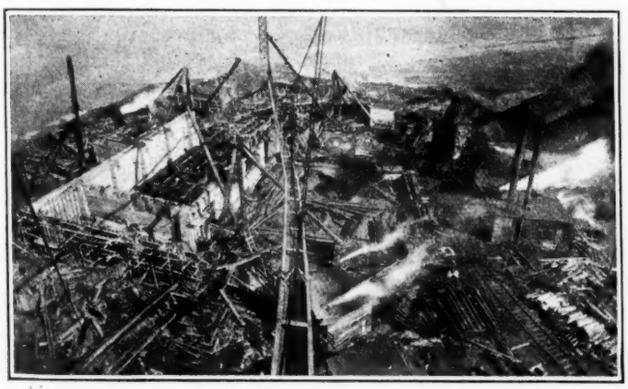


Fig. 3—Late view showing status of construction

install a rotary car dumper later. The coal will be crushed and elevated to the top of the boiler house by a bucket elevator and distributed to the raw-coal bins by a scraper conveyor. From these bins the raw coal passes through flue-gas coal driers to the pulverizers on the basement floor. The pulverized coal is carried to separators and fed into the pulverized-fuel bins, of which there are four, of 75 tons' capacity each, directly in front of the boilers. The pulverizers, which are to be of six tons capacity per hour, and the driers are to be installed on the unit plan: that is, one per boiler with one spare pulverizer that can feed to any one of the four pulverized-fuel bins.

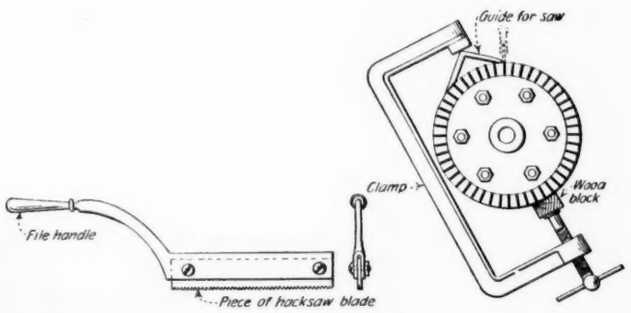
Current will be generated at 13,200 volts, and that portion of it intended for local consumption will be sent across the river at this voltage through submarine cables to the Peoria plant. Another portion of the station output will be stepped up to 132,000 volts to supply the Illinois Power Co., at Springfield, Ill., 70 miles south, and there will be other transmission lines supplying the surrounding territory for a considerable radius. All cables go out underground. The truss directly over the turbine room provides room for a cable gallery. At the end of the office section of the building these cables go down a stack and out to the underground manholes. In the feeder circuits 3 per cent reactors will be used, and between generators in a ring bus system 5 per cent reactors.

Engineering for the plant is to be credited to the local organization. The foundation work, which is now practically completed, has been done by the Foundation Co., of New York City.

Guide for Undercutting Commutators by Hand

By M. M. Brown

In some electric machines trouble is experienced from high mica between the commutator segments. This is usually due to extremely soft copper segments wearing away faster than the mica insulation, leaving the mica



Guide is clamped on the commutator parallel with the edge of the slot

projecting. Sometimes, where poor mica is used, the heat and pressure cause the mica to squeeze out.

Turning down the commutator will usually cure the trouble, but in some cases it will occur again and again. A more permanent cure is to undercut the mica. Some engineers object to this method, as more care is necessary in cleaning the machine, because if carbon or copper dust collects in the slots it may cause short-circuits between adjacent segments. In plants having tools and facilities for doing machine work, the slotting can be done readily enough but cutting out the grooves by hand is tedious work and requires a great deal of patience, as one is troubled by the tool slipping out of the groove and scratching the segments.

The sketch shows a device used in one plant for this work. A piece of $\frac{3}{8}$-in. iron plate having straight, smooth edges was bent at right angles to serve as a guide for the saw. A clamp was used to hold the guide in position, with a block of wood at the other side to prevent marring the commutator. A short saw-frame was made from $\frac{1}{4}$-in. steel with two stove bolts to hold the piece of blade firm. After slotting the mica ($\frac{1}{4}$ in. is sufficient) a fine mill file should be rubbed lightly on the commutator to remove any burrs that may be left by the saw. Then, after sandpapering, the slots should be thoroughly cleaned out with a stiff-bristled brush. This should also be done after each time the machine has been in service.

Effect of Excess Air on Flue Temperatures and on Efficiency

VARIATION in air quantity has a direct effect upon the mass of flue gas discharged and also gives rise to changes in flue-gas temperature. Air quantity thus has an important bearing on boiler losses and efficiency. This article gives the results of tests made at Connors Creek to establish the relation between excess air and stack gas temperature for a particular boiler and setting.

By A. KRISTIAN BAK
Detroit Edison Company

THE losses incurred in boiler operation are: Loss through chimney; loss due to carbon in refuse; loss due to radiation, etc.; loss due to banking and starting fires. It is well known that of these losses the first mentioned is by far the most important and, if the boilers are in fairly good condition, practically the only one that offers any possibility of improvement. Excessive chimney losses may be caused either by dirty boiler tubes or by the use of too much air. The dirtiness of the boiler tubes has a marked influence on the gas temperature and stack-gas losses. P. W. Thompson, in his paper on "Tests on a Type W Stirling Boiler at Connors Creek Power House, etc.," presented before the A.S.M.E. meeting December, 1922, shows that steaming a boiler for 24 hours at 150 per cent of rating without using the flue-blowing units results in an increase in stack-gas temperature of 47 deg. F., and that by blowing the tubes every four hours the increase may be kept within 6 degrees.

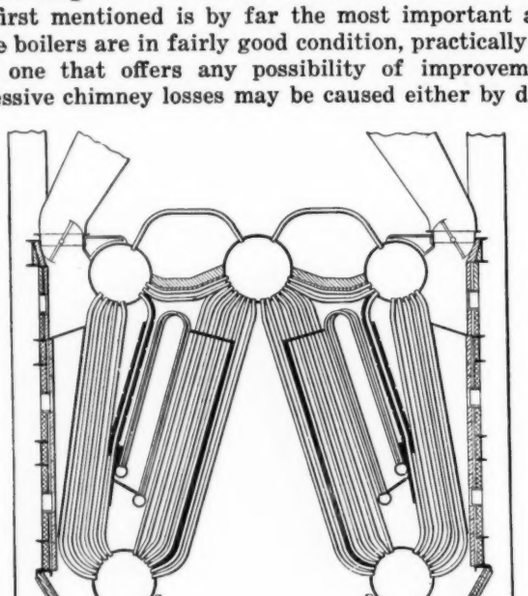


Fig. 1—Type of boiler and setting on which tests were made

Water-heating surface, 23,650 ft.; superheating surface, 2,996 sq.ft.; stokers, two 13-retort underfeed.

For the purpose of studying the effect of excess air, it may be well to divide the stack-gas losses into the following three items: Loss in dry gas; loss due to water vapor in gas; loss due to unburned combustible gas. Each of these varies with the excess air although in a different manner.

The well-known formula for the dry-gas losses is

$$\textit{Loss, B.t.u. per lb. of coal} = G \times c \times (T - t)$$

where

G = Weight of dry gas per pound of coal;
c = Specific heat of dry gas;
T = Temperature of gas leaving boiler;
t = Temperature of air entering furnace.

Any change in excess air affects both G and T in the same direction; that is, an increase in excess air increases both G and T and, therefore, to a marked degree the product of the two.

The loss due to vapor in gas is

$$\textit{Loss, B.t.u. per lb. of coal} = W \times (H - h)$$

where

W = Weight of water vapor per pound of fuel;
H = Total heat of low-pressure steam at exit-gas temperature;
h = Specific total heat of vapor at air temperature or of liquid water at fuel temperature, depending upon whether the water vapor is from air or fuel, respectively.

W is the sum of the initial moisture in the coal, the water formed by burning the hydrogen in the fuel and the moisture in the air supplied for combustion. Only the last item varies with excess air, and as it is only a small fraction of the total water, W is practically independent of the excess coefficient. The total heat H varies directly with the temperature.

Keeping Stack Loss a Minimum

The loss due to unburned gas is the heat of combustion in the gas. Up to about 13 per cent of CO_2 the amount of unburned combustible gas is usually negligible. Above that point it begins to be of importance. How fast it increases with increasing CO_2 depends on the type of furnace and grade of coal burned. The increased loss due to unburned combustible gas at high CO_2 content will partly offset the gain in dry-gas loss, and it is evident that the highest CO_2 is not necessarily the most economical, since maximum economy corresponds with the minimum sum of all losses rather than with the minimum of any one loss.

To determine the best point of operation, it is necessary to know the relation between excess air and exit-gas temperature at constant ratings on the boiler as well as the variation in the amount of unburned combustible gases. Calculated values of the exit-gas temperature for two different percentages of CO_2 are given by A. D. Pratt in the Report of Prime Movers Committee of the N.E.L.A. for 1921 (page 75); the figures, however, are for a constant amount of coal burned and not for constant rating.

In spite of a diligent search the writer found no

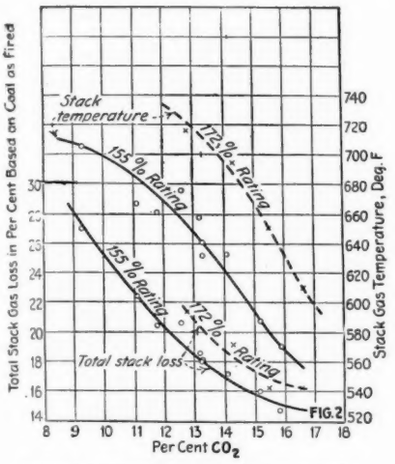
data on this subject covering a wide range of CO_2 percentage, so the tests described in this article were undertaken to determine this relation as well as the best point of operation for this particular furnace.

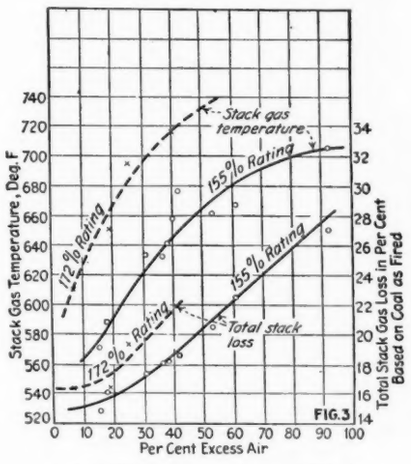
The tests were made on one of the boilers at the Connors Creek Plant of the Detroit Edison Co. The boiler has 23,650 sq.ft. of water-heating surface, is equipped with a 2,996-sq.ft. superheater and is fired by two 13-retort 2-ram Taylor stokers. Further data on this boiler are given in the paper by P. W. Thompson already mentioned. A cross-section of the unit is shown in Fig. 1.

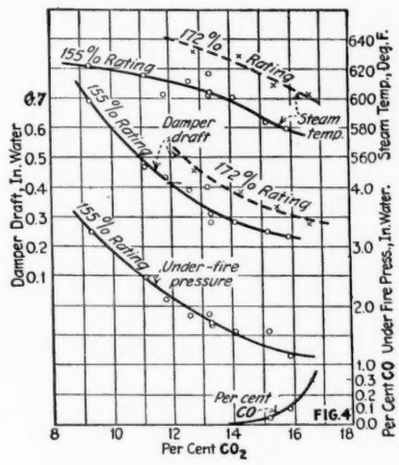
The tests were made as a study of temperatures and gas analysis only, and no attempt was made to determine the efficiency of the boiler during the tests, therefore coal and feed water were not weighed. The gas temperatures were obtained by the use of thermocouples, three being installed under the damper on each side of the boiler and connected to a potentiometer which recorded the temperature of each side separately; the average of the two sides is used in the curves. The couples were shielded to minimize radiation errors and were located about 13 in. from the drum, at which point the temperature was the highest. Orsats were used for making the gas analyses, an automatic CO_2 recorder being used as a check. The samples were a mixture of gas from four points on each side of the boiler.

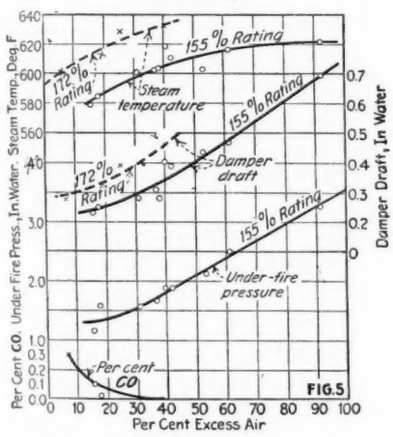
Steam temperatures were measured by calibrated glass thermometers in wells located at the non-return valve on each superheater outlet. The rate of steaming was determined from a flow meter, an accurate determination of the absolute rating being of minor importance as long as it was the same for the different runs. No determinations were made of the humidity of the air, and the loss due to moisture in air is not included in total stack-gas losses. All meters and instruments were checked prior to the test. The tubes were blown every four hours in order to eliminate as far as possible the effect of variation in the dirtiness of the boiler tubes.

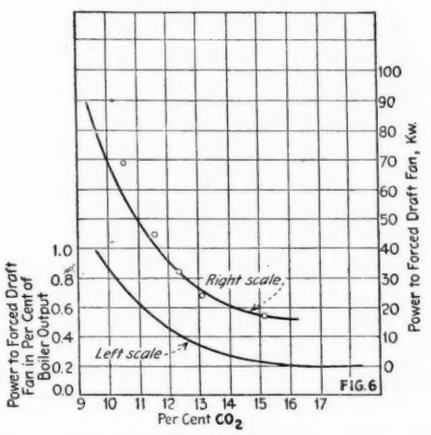
Two series of tests were made at approximately 155 per cent and 172 per cent of rating. At the higher rating it was impossible to hold the rating when trying to carry much below 12 per cent CO_2. The duration of each test was from one to two hours, during which period readings were taken every ten minutes, the readings later being checked against the averages from the charts of recording instruments. Each test was preceded by a sufficiently long period at as near as possible to the same conditions as during the test, during which time conditions could be expected to become settled. The results of the tests are plotted in Figs. 2 to 8.

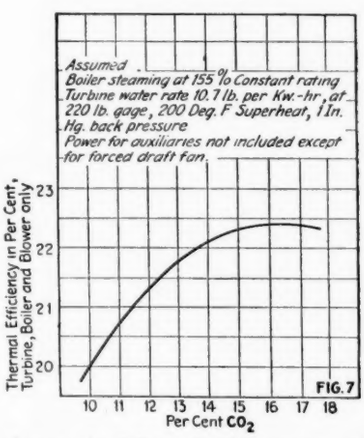

Total Stack Gas Loss in Per Cent Based on Coal as Fired
Stack temperature
155 % Rating
172 % Rating
Total stack loss
Stack Gas Temperature, Deg. F
Per Cent CO_2
FIG. 2


Stack Gas Temperature, Deg. F
Stack gas temperature
155 % Rating
172 % Rating
Total stack loss
Total Stack Gas Loss in Per Cent Based on Coal as Fired
Per Cent Excess Air
FIG. 3






Right scale
Left scale
Power to Forced Draft Fan in Per Cent of Boiler Output
Power to Forced Draft Fan, Kw.
Per Cent CO_2
FIG. 6


Assumed
Boiler steaming at 155 % Constant rating
Turbine water rate 10.7 lb. per Kw.-hr., at 220 lb. gage, 200 Deg. F Superheat, 1 In. Hg. back pressure
Power for auxiliaries not included except for forced draft fan.
Thermal Efficiency in Per Cent, Turbine, Boiler and Blower only
Per Cent CO_2
FIG. 7

Figs. 2 to 6—Variation of temperatures, drafts, fan power, losses, etc., with change in CO_2 and with excess air.
Fig. 7—Effect of percentage of CO_2 on over-all plant efficiency (values shown are relative only)

The stack-gas temperature increases rapidly with decreasing percentage of CO_2 (see Fig. 2). Between 15 and 13 per cent the curve is practically a straight line and shows an increase of 27 deg. F. for each one per cent drop in CO_2. The total increase between 16 per cent and 9 per cent CO_2 is 138 deg. The effect on

the total stack-gas losses is shown on the same curve sheet. Below 14 per cent CO_2 each one per cent decrease gives approximately 2 per cent increase in the losses, and the total increase betwen 16 and 9 per cent CO_2 is 13 per cent.

The minimum point on the total-loss curve is evidently at or above 17 per cent CO_2; the exact location was not determined because of the difficulty of maintaining such high CO_2 for any length of time. The very fact that the minimum is at such high CO_2 makes it of little value to know the exact point, as for all practical purposes the rule may be given that for this boiler the highest possible CO_2 is the best. In Fig. 3 the stack-gas temperature and total losses have been plotted against percentage of excess air.

The steam temperature increases with decreasing

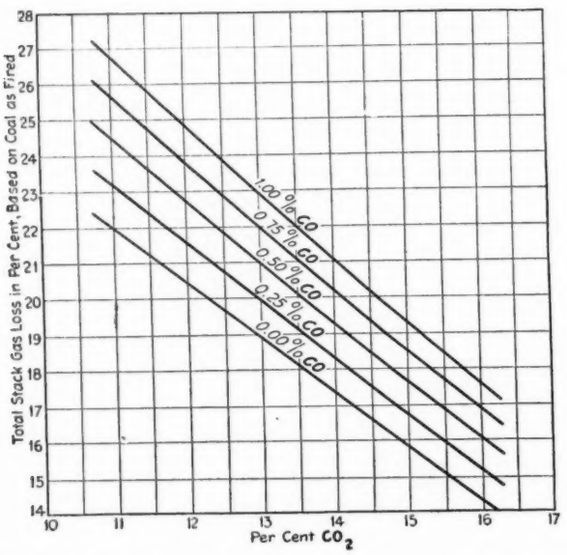


Fig. 8—How CO_2 and CO affect percentage of stack loss

CO_2, the total increase being 44 deg. in changing from 16 to 9 per cent CO_2. (See Fig. 4.)

The underfire pressure and damper draft both increase rapidly with decreasing CO_2 (see Fig. 4), due of course to the larger volumes passing through the fire and boiler. The increased volume of air handled by the forced-draft fan and the higher underfire pressure will increase the power consumption of this fan considerably, approximately in proportion to the product of the volume and pressure. The marked increase in power consumption will be seen from Fig. 6, which shows the power input to the forced-draft fan and the power consumption in percentage of boiler output. The power input is practically four times as large at 10 per cent CO_2 as at 16 per cent. This increase in energy used by the fans is another inducement for holding the excess air down as far as possible in order to decrease the auxiliary power consumption of the station.

The readings on power consumption were not taken at the same time as the others, but at a later date; however, the same rating was carried (155 per cent), the same grade of coal burned and the thickness of the fuel bed so adjusted as to get practically the same underfire pressures as on the previous tests. The power input in percentage of boiler output was computed, assuming a turbine steam rate of 10.7 lb. per kw.-hr. at 220 lb. throttle pressure, 200 deg. F. superheat and one inch of mercury back pressure, and the conversion from alternating current to direct current through motor-generator sets.

In a power plant, where the final product is electricity and not steam, the goal to strive for is not the highest possible boiler efficiency, but the highest possible plant efficiency. That the two efficiencies do not coincide will be seen from the fact that lowering the boiler losses by higher CO_2 also lowers the temperature and the total heat of the steam leaving the boilers, which in turn affects the turbine operation by increasing the steam rate and decreasing the thermal efficiency, the change in steam rate being about one per cent for every 11-deg. drop in temperature. It is evident, then, that the most economical point of operation for the complete plant will be at a somewhat lower CO_2 than for the boiler room alone.

To bring this point out, a curve has been plotted in Fig. 7, showing the variation of thermal efficiency with CO_2 for a plant consisting of boiler, turbine and forced-draft fan, using the values for losses and temperatures shown on the previous curve sheets and assuming, as before, a steam rate of the turbine of 10.7 lb. per kw.-hr. at 220 lb. pressure, 200 deg. F. superheat and one inch of mercury back pressure. To simplify matters, the boiler was assumed to be steaming at a constant rating of 155 per cent and all auxiliaries except the forced-draft fan were excluded.

Proper CO_2 for Best Over-all Result

The variation in steam temperature and turbine steam rate will of course affect the total feed water for a given output as well as the heat lost to the condenser, and through them the power input to feed pumps and circulating pumps; also the change in boiler efficiency affects the amount of coal burned and the power used by stokers and coal-handling equipment. However, the percentage change in power consumption for all those auxiliaries will be small compared with that of the forced-draft fan and will not alter the shape of the curve. Although the curve as plotted does not show the actual plant efficiency, but is 4 or 5 points too high on the scale, it has the same shape and therefore shows variations in efficiency the same as would the actual efficiency curve. It will be seen that the best point is at about 16.2 per cent CO_2, whereas the highest boiler efficiency is obtained at or above 17 per cent. This means a lowering of the point of most economical boiler operation by approximately one per cent.

The lowering of the flue-gas temperature by increasing the CO_2 will partly offset the loss from CO, and the most economical operation will not be with zero CO. Fig. 4 shows that at the best point there is about 0.20 per cent CO in the flue gas. The total stack-gas loss for given percentages of CO, taking into consideration the variation in gas temperature, has been plotted in Fig. 8. The curves show that a considerable amount of CO may be justified. For instance, it will be seen that 15 per cent CO_2 with 0.25 per cent CO is more economical than 14 per cent CO_2 and no CO and equal to 15.5 per cent CO_2 with 0.5 per cent CO.

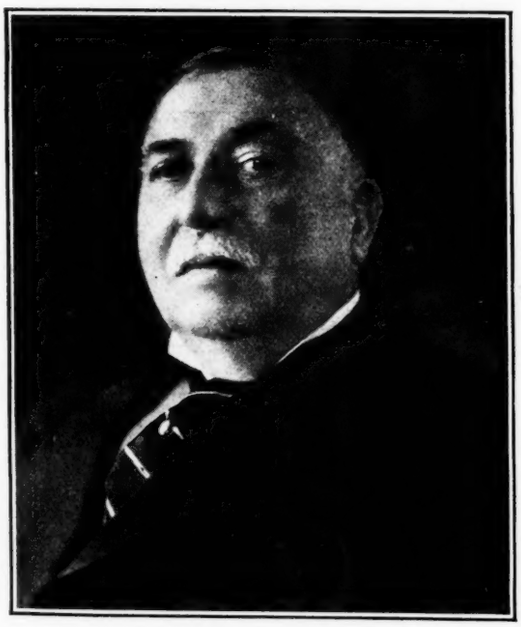
In applying these results to other installations it must be remembered that they can be taken only as an indication of what to expect. Several factors, such as type of boiler, combustion condition and grade of coal, influence the results, either by changing the stack-gas temperature or by affecting the point at which combustible gas appears in the flue gas.

First Steel Boiler Made for Mechanics Fair, Boston

Story of How Steel Was Decided Upon After Many Tests by D. M. Dillon

WHILE reading the "Reminiscences of a Veteran Mechanical Engineer," by W. H. Odell, many of the older men were reminded of their early experiences along similar lines. Among these men was D. M. Dillon, who constructed the first steel boiler for the Mechanics Fair at Boston.

Mr. Dillon, who was born at St. John, New Brunswick, in 1843, was a boilermaker from the age of fourteen, when he entered the shop of Thomas Ranton, St. John, where he spent four years learning the trade and received $2 per week during this time. Later, he secured employment with the Dugald, McLaughlin Boiler Co., St. John. In 1860 he decided to try his fortune in the United States, so he secured work in the Atlantic Works, East Boston. On account of a labor



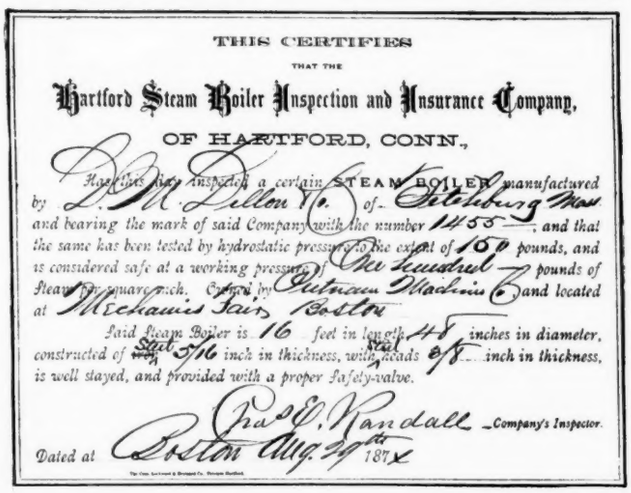
David M. Dillon

strike he went to New York, where later he entered the Quartermaster's Department of the United States Army and was stationed at Port Royal, S. C., making repairs on Army transport vessels.

During the spring of 1866 he, with Charles Stewart, started the boiler-making concern of Stewart & Dillon, which continued for four years. In 1870 Mr. Dillon went to Fitchburg and started the D. M. Dillon Steam Boiler Works, making wrought-iron boilers, penstocks, heavy plate-iron work, smoke flues, etc.

In 1874 the Mechanics Fair was held in the upper story of Quincy Market, Boston, Mass., and as they had to have power in the building, the contract for engines and boilers was awarded to the Putnam Machine Co., Fitchburg, Mass., who sublet the two boilers required to D. M. Dillon, also of Fitchburg, one of the many boiler manufacturers in Massachusetts at that time.

These boilers were to be constructed from the best locomotive flanged iron and were 48 in. in diameter by



THIS CERTIFIES

THAT THE

Hartford Steam Boiler Inspection and Insurance Company,

OF HARTFORD, CONN.,

Have this day inspected a certain STEAM BOILER manufactured by D. M. Dillon No. of Fitchburg Mass and bearing the mark of said Company with the number 1455, and that the same has been tested by hydrostatic pressure to the extent of 150 pounds, and is considered safe at a working pressure of One hundred pounds of Steam per square inch. Owned by Putnam Machine and located at Mechanics Fair Boston

Said Steam Boiler is 16 feet in length 48 inches in diameter, constructed of Steel 5/16 inch in thickness, with heads 5/8 inch in thickness, is well stayed, and provided with a proper Safety-valve.

Dated at Boston Aug. 29 1874 Jno. E. Randall Company's Inspector.

Facsimile of certificate of inspection of steel boiler at Mechanics Fair, Boston

16 ft. long, made in four courses. Just at the time the contract was placed, the Bay State Iron Co., South Boston, Mass., had finished experimenting on the making of open-hearth steel, and after examining their product, Mr. Dillon saw no reason why these steel plates could not be used in boilers instead of iron. After a great deal of pressure had been brought to bear upon the directors of the Mechanics Fair, they reluctantly allowed him to substitute steel for iron, although they had little faith that the steel would make good. Mr. Dillon also had a lot of trouble in convincing the Putnam Machine Co. that steel could be used in place of iron, but after many arguments and a great deal of hard work, steel was allowed in this case. This material was first called homogeneous metal, and afterward, homogeneous steel. Mr. Dillon decided to use steel only after making exhaustive tests in the boiler shop upon samples sent him, and in every instance these samples showed up better than any iron he had ever worked.

The Bay State Iron Co., after having made this homogeneous steel, had great difficulty in getting a market for it, and it was through Mr. Dillon's friendship that J. Avery Richards, treasurer of the company, finally began to look to boilermakers to dispose of his product.

The tests made by Mr. Dillon upon these samples of steel were the bending tests, tensile strength, which was found to be about 72,000 lb. per sq.in., and the

quenching test, the material showing up all right in each case. Many of his competitors claimed that this steel, when put through the quenching test, would become brittle and the boilers would explode in a short time, but he decided, from the results of his own tests, that a steel boiler would last as long as, if not longer than, iron, and his judgment proved to be correct. The price of steel at this time was 8.6c. per pound.

Mr. Dillon worked, personally, on both these boilers, to make sure they were constructed exactly right.

No. 1455 BY THIS POLICY OF INSURANCE, $1400

THE

Hartford Steam Boiler Inspection and Insurance Co.,

OF HARTFORD, CONN.

In Consideration of the Receipt of Five and 00 Dollars, do Insure

D. M. Dillon & Co.

their legal representatives, or parties to whom they may assign or transfer this Policy, (as per form on back,) to the amount of One Hundred Dollars, on one Steam Boiler, designated by the number 1455 against all such immediate loss or Damage as shall be caused to the property specified by Explosion or Rupture from the action of steam, from the twenty-third day of August eighteen hundred and seventy-four at 12 o'clock, noon, unto the twenty-third day of August eighteen hundred and seventy-five at 12 o'clock, noon: to be paid at said Hartford, within thirty days after notice and proof of loss has been made by the assured.

It is expressly Covenanted, That this Company is not liable, under this Policy, for Loss or Damage resulting from the burning of the building or manner in which said Boiler may be used, nor for Loss or Damage to any Steam Boiler not provided with a proper Steam Gauge; and that in no case shall the claim be for more than the actual and immediate damage incured against, estimated according to the true cash value of the property at the time of the explosion.

In Witness Whereof, The HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY have caused these presents to be signed by their President, and attested by their Secretary, this 24th day of August 1874, but the same shall not be binding on the Company until countersigned by

L. B. Pierce Secretary. J. M. Allen President.

Countersigned at Boston Mass this 24th day of August 1874 W. B. Farnsworth Jr. Agent.

Facsimile of insurance policy issued on first steel boiler to David M. Dillon

They were, as already stated, 48 in. in diameter by 16 ft. long, with $\frac{5}{16}$-in. shells and $\frac{3}{8}$-in. heads, and were made in four courses, one plate to a course. Previously, boilers were built with two plates to a course. The heads were made in one piece and nicely flanged. The plates for these boilers were the largest the mill had ever rolled, and the whole process was watched carefully, but the plates came out in perfect condition. The boilers were constructed with double lap-riveted joints and single girth seams. Each one contained fifty 3-in. by 15-ft. iron tubes and had seven $1\frac{1}{4}$-in. crowfoot braces on each head, made of round iron with flat ends welded on and connected to 4x$3\frac{1}{2}$-in. T-iron riveted to heads. Rivets of $\frac{7}{8}$ in. were used in the construction of these boilers, which were built for 100 lb. working pressure and tested to 150 lb. by the Hartford Steam Boiler Inspection & Insurance Co., Charles E. Randall, Inspector.

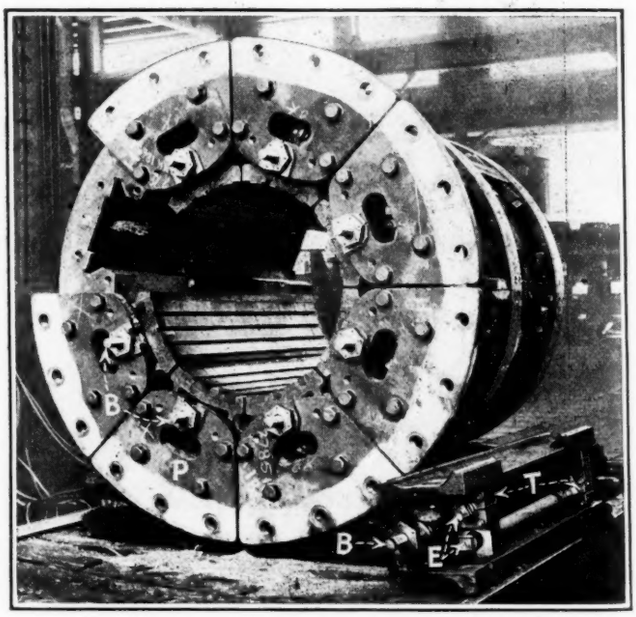
After the boilers were finished and partly bricked in, Mr. Dillon was called hurriedly to Boston, by telegraph, to confer with the committee on power, who had decided that the boilers would not be safe and must be taken out and wrought-iron ones installed. This action was due largely to the influence of some of the other boiler manufacturers, who felt that wrought iron was good enough. Mr. Dillon, however, explained carefully the tests he had made and the manner in which the plates were worked and finally persuaded the committee to allow the boilers to remain, and said that, if necessary, he would sit on top of one of them throughout the fair. This statement showed he was in earnest and believed the steel plates were all right, so his steel boilers were installed and used for power during the exposition.

It was quite a few years before other boiler manufacturers built any steel boilers and also some time before many manufacturers would allow steel boilers to be used in their plants, as they did not want to take any chances of explosions. At the present time wrought-iron boilers are almost obsolete.

Adjustable Lignum-Vitae Guide Bearing for Hydraulic Turbines

With the increase in size and the importance of maintaining high efficiency in hydraulic turbines, refinements in design, become of ever-increasing importance. One source of loss in a hydraulic turbine is the leakage through the runner seals. If this loss is to be maintained at a low value, close clearances must be worked to, which means that the turbine guide bearing must operate with small tolerance.

To provide a means of adjusting the clearance in the turbine guide bearing, the Wm. Cramp & Sons Ship and Engine Bldg. Co. has developed an adjustable type of bearing. This bearing is made of 8 tapered sections, each one guided in machined tapered grooves as shown in the figure. A bolt *B* connected to each section extends through the segment of a heavy circular plate *P* bolted to the top of the bearing housing. A nut is provided on this bolt as a means of moving the sections of the bearing in the tapered grooves for adjusting the shaft clearance. After the bearing has been



Adjustable guide bearing with one section removed

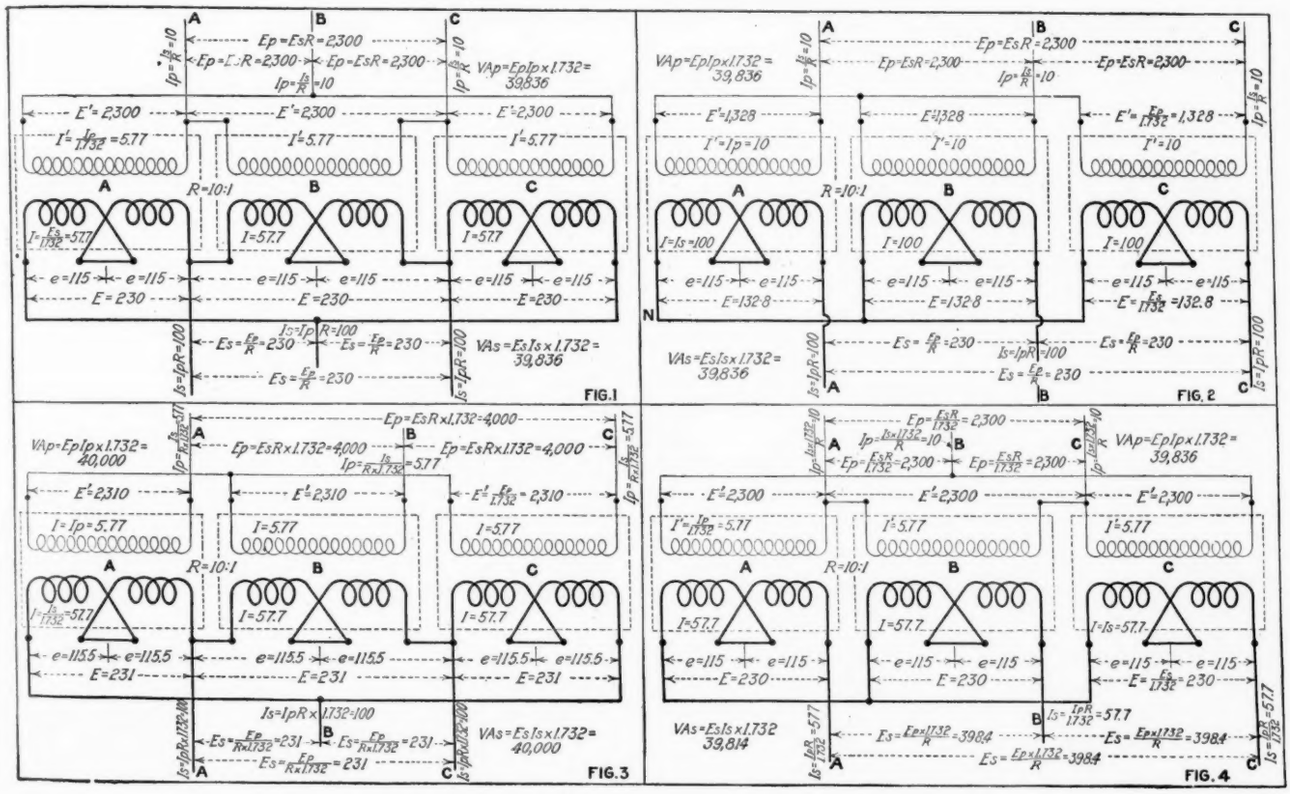
adjusted, each section is locked rigidly in place by expansion bolts *E*, which are screwed into tapered holes at *T* and expand the sides of the section to take up any slight clearance there may be in the grooves.

This type of bearing is being used on the two 70,000-hp. turbines built by this company for the Niagara Falls Power Co., one of which is now in operation, and the two 20,000-hp. units recently installed in the Holtwood plant of the Pennsylvania Water & Power Company.

Transformers Connected for Operation on a Three-Phase Circuit

By B. A. BRIGGS

EITHER two or three single-phase transformers grouped in a bank or a three-phase transformer may be used to step up or step down the voltage of a three-phase circuit. Where a three-phase transformer is used, the connections are simple, as there are usually only three terminals on the primary and three on the secondary side to be contended with, and one line is connected to each of the three. When three single-phase transformers are used, there are four different ways they may be grouped: Delta to delta, star to star, delta to star and star to delta. In addition to these connections two single-phase transformers may be grouped open delta for the same purpose. When transformers are to be grouped on a three-phase circuit, it is necessary that all transformers in the same bank have like characteristics. Fig. 1 shows the connections for three single-phase transformers grouped delta to delta. This scheme of connections is one that is widely used, and in so far as the line volts and current are concerned the ratio is the same as for a single transformer. For example, the primary volts E_p equals the secondary volts E_s times the ratio R, or $E_p = E_s R = 230 \times 10 = 2{,}300$. Where the load is balanced, the current in each line is equal to the current in one transformer times the $\sqrt{3}$ (1.732). For example, on the primary side lead A connects between transformer A and B, and the current in this lead is the resultant of the current in the primary of transformers A and B, or $I_p = I' \times 1.732 = 5.77 \times 1.732 = 10$ amperes. As indicated in the diagram, the current in the primary of each transformer is $I' = \frac{I_p}{1.732} = \frac{10}{1.732} = 5.77$ amperes. The same reasoning that applies to the primary also holds for the secondary,



Figs. 1 to 4—Three transformers grouped in delta and star connections

Fig. 1—Delta to delta. Fig. 2—Star to star. Fig. 3—Delta to star. Fig. 4—Star to delta.

and the expressions are given on the diagram for determining the different values of current, voltage and volt-amperes.

One way of determining the volt-amperes of the three transformers would be to multiply the product of the volts and amperes of one transformer by three, or on the secondary side this is $230 \times 57.7 \times 3 = 39{,}813$. Another way to obtain the volt-amperes is to use the formula given on the figure, which reads that the volt-amperes equals the voltage between leads times the current in one lead times 1.732. On the secondary side the volt-amperes $VA_s = E_s I_s \times 1.732 = 230 \times 100 \times 1.732 = 39{,}836$. This checks with the other method within the error of the decimal. The watts would be obtained by multiplying the volt-amperes by the power factor.

In the connection, Fig. 2, which shows three single-phase transformers connected star to star, the values are the same for the delta-to-delta connections with the exception of the value on the individual transformer. In this connection it will be seen that the current in the individual windings is the same as in the leads, since only one lead connects to each winding. Tracing the circuit between any two leads will show two transformers connected in circuit. For example, transformers *A* and *B* are connected in series between leads *A* and *B*. This results in the voltage on the individual windings being less than between leads. If the two windings were directly in series across a single-phase circuit, each winding would have one-half of the line voltage across its terminals. In this case the windings are connected on a three-phase circuit which results in the voltage per transformer equaling line volts divided by 1.732. On the primary side the voltage on one transformer is $E' = \frac{E_p}{1.732} = \frac{2,300}{1.732} = 1,328$. This is the voltage that the transformer would have to be built for if they are to be connected star to star on a 2,300-volt three-phase circuit, or for about 58 per cent of line voltage. Although the winding in star-connected transformers need have only 58 per cent of the turns for delta-connected transformers, the current capacity of the former has to be 73 per cent greater than the latter for the same capacity. For example, on the primary side in Fig. 1 the windings have to be good for 5.77 amperes, whereas in Fig. 2 this winding has to be good for 10 amperes, which is (10 × 100 ÷ 5.77) — 100 = 73 per cent greater.

On a 4,000-volt three-phase line three single-phase 2,300- to 230-volt transformers can be connected star on the primary and delta on the secondary to step down

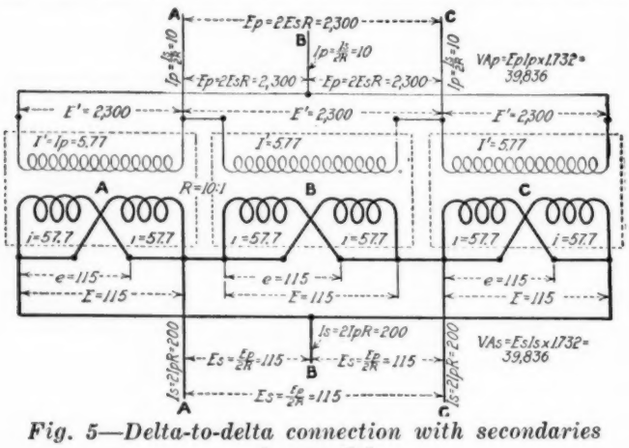


Fig. 5—Delta-to-delta connection with secondaries in parallel

to 230 volts, as in Fig. 3. In this case the ratio of the transformers are the same as in the other two figures, but owing to connecting the windings star on one side and delta on the other, the ratio of the line volts is changed by 1.732, or when the ratio of the transformers is 10.1, for the line volts it is 17.32:1. As an example the primary volts, $E_p = E_sR \times 1.732 = 231 \times 10 \times 1.732 = 4,000$.

Another grouping of three single-phase transformers is the delta-to-star connection, Fig. 4. With this connection and 2,300 volts applied on the primary, the secondary will develop about 400 volts, which might be used as a temporary means of operating 440-volt motors. In this case, although the ratio of the transformers is the same as in the other figures, the ratio of the line volts has been decreased by 1.732, which makes the ratio only 5.77:1. As an example as to how this works out, take the secondary volts, $E_s = \frac{E_p \times 1.732}{R} = \frac{2,300 \times 1.732}{10} = 398.4$. A slight variation will be found in some of the figures in both Figs. 3 and 4, which is due to the error in the decimals.

By connecting the three transformers used in Fig. 1 as in Fig. 5, the voltage would be stepped down to 115

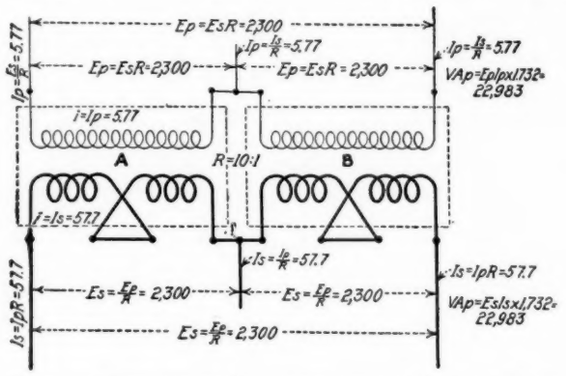


Fig. 6—Two transformers connected open-delta

instead of 230. In Fig. 5 the two sections of the secondary of each transformer have been connected in parallel instead of series, as in the previous figure. This cuts the secondary volts in half, but the current capacity is doubled, so that the power output of the bank has not been altered. Connecting the two sections of the secondary winding in parallel has the same effect as doubling the ratio of the transformers, and this has been taken care of in the different expressions for finding the volts and current, by multiplying the ratio by 2, thus $E_s = \frac{E_p}{2R} = \frac{2,300}{2 \times 10} = 115$ volts.

One of the advantages of a closed-delta connection, Fig. 1, is that in case of trouble in one transformer the unit at fault may be disconnected from the system and the two remaining transformers connected open-delta, Fig. 6, and used to carry 57.7 per cent of the normal load. In this connection the volts on all three phases are equal as in the closed-delta connection and the ratio of the volts and current is the same as for the three transformers in Fig. 1. The transformers in Fig. 6 have been assumed to have a rating equal to those in Fig. 1, so that the low-voltage winding will be good for 57.7 amperes and the high-voltage windings can take a load of 5.77 amperes. Since the outside leads connect to only one transformer, the current in both will be the same. The center line connects to two transformers, but the relation between the currents supplied by the two windings is such that the current in the middle leg is the same value as that in one of the outside leads.

In the open-delta connection each transformer carries not only the load connected directly to it, but also additional load connected across the two outside legs of the circuit, which is supplied by the two transformers. On account of the resultant of the two currents supplied by each transformer being out of phase by 30 deg. with the transformer voltage at unity power load, each trans-

former has a power capacity of only 0.866 per cent of its closed-delta rating at unity power factor. At unity power factor load the volt-ampere load that could be supplied by one transformer is equal to volts times amperes times 0.866. For the two transformers the volt-ampere load that can be supplied is volts of one phase times the current in one of the outside legs times 0.866×2. The product of the last two factors is $0.866 \times 2 = 1.732$. Therefore in the figure, on the high-voltage side the volt-amperes $VA_p = E_p I_p \times 1.732 = 2{,}300 \times 5.77 \times 1.732 = 22{,}983$. This value is not 66 per cent of the load on the three transformers, Fig. 1, but $22{,}983 \div 39{,}836 = 57.7$ per cent. In other words, two transformers connected open-delta will have a capacity equal to only 57.7 per cent of three similar transformers connected closed-delta. Another objection to the open-delta connection is that its voltage regulation is not so good as the closed-delta connection.

Relative Merits of Different Types of Motor Bearings

By F. E. Boyd*

Much advertising has been given to ball and roller bearings, but little has been said about the merits of sleeve bearings. This is due to the fact that they are not made by any one company solely interested in sale, but are made by practically every machinery-manufacturing company, which builds them of various designs as an incident to other work. Sleeve bearings have been in existence so long that their merits are assumed to be well known. It is quite natural that publicity on the one hand and complete lack of publicity on the other would favorably impress some prospective purchasers with the universal desirability of ball and roller bearings. When properly built and correctly applied, each type of bearing (ball, roller and sleeve) has its special field.

The bearing in general-purpose industrial motors presents a special problem, the solution of which is by no means obvious. The problem may be considered from the designer's, the manufacturer's or the user's point of view. The following considers the question from the user's viewpoint:

Ball bearings have much less static friction than sleeve bearings, but there is little to choose in running efficiency between the different types of bearings. If the difference in static friction between ball and sleeve bearings were important, it would be evidenced in better guaranteed starting torques of ball-bearing motors. If there were any difference in the running efficiencies worth mentioning, this would be evidenced in better efficiency guarantees by motor manufacturers using ball bearings. The facts are that manufacturers of motors employing sleeve bearings give the customer the best starting torque and running efficiency guarantees that are to be obtained.

More exact and fixed alignment may be secured by the use of ball bearings, but it is also a fact that a more exact alignment is necessary and must be maintained for the successful operation of ball bearings than is required by sleeve bearings. It is really splitting hairs to talk much about more exact alignments by ball bearings, because years of experience have demonstrated that sleeve linings provide alignment exact enough for all ordinary requirements. Sleeve-bearing motors have operated for years when the original air gap was only 15 mils. For general-purpose motors the practical limits for commercial mechanical construction for other parts are such that it would not be wise to decrease air gaps below the present limits, and as this cannot be done, there is little gained by ball bearings. Ball-bearing manufacturers emphasize the need for fixed alignment in gear drives and tell how this will increase the life of gears. This is a fact, but one must not forget that little is gained by the ball bearings unless the motor can be mounted on the machine extremely accurately. There would be nothing gained by having ball bearings on the motor and a sleeve bearing on the shaft of the driven gear. Gear drives often transmit or produce vibrations and hammering effects very destructive to ball bearings.

One finds literally hundreds of cases of electric motors in operation from 10 to 25 years with sleeve bearings, but how frequently will we find ball bearings that have seen such service? Sleeve bearings wear out slowly, but when ball bearings start to wear out they go to pieces very rapidly. At high speed sleeve bearings operate more quietly than ball bearings.

Sleeve bearings are obviously the most simple and rugged bearings built. They will stand more abuse and neglect. It is easy to injure ball bearings permanently when driving on a pulley or pressing on a gear.

Most modern sleeve bearings are well protected from grit and dust. Ball bearings must be positively protected from these, as their life will be much less in the presence of deteriants than will be the life of sleeve bearings. In some quarters there is an impression that ball bearings require little lubrication. The catalogs of ball-bearing manufacturers certainly do not substantiate such an impression; in fact, the successful operation of ball bearings frequently depends upon a highly refined difference in oil or grease to be used.

That all types of industrial apparatus are liable to fail through improper use or neglect is a recognized fact. It is also recognized that there is no comparison either in the favorable cost or in the case of replacement of an ordinary sleeve bearing with a ball bearing. Under emergencies sleeve bearings can be made at the nearest machine shop. Just as a degree of balance that would be satisfactory for a device rotating at 300 r.p.m. would not be satisfactory for a device rotating at 3,600 r.p.m., so the degree of fit which is suitable in slow revolving parts will not be successful at higher speeds.

Sleeve bearings offer a broader support to take up shocks and strains. Ball bearings, being highly refined and requiring delicate adjustment, are more subject to injury and misplacement during transportation and installation than are sleeve bearings.

Unquestionably, all types of bearings when properly built, correctly applied and properly cared for have their proper application. The proper bearings for electric motors are largely a matter of selection in the interest of the majority of users, and it is significant to note that practically every manufacturer of motors is using sleeve bearings for general-purpose motors. It cannot be fairly said that manufacturers are arbitrarily opposed to ball bearings, because it will be found that the same manufacturers have and do apply ball and roller bearings for certain special installations.

*Assistant Sales Manager, San Francisco office, General Electric Co.

Development of the 12,000-Horsepower Nurnberg Diesel*

By W. LAUDELIN

AFTER a number of cylinders for the 12,000-hp. Diesel had been built and discarded, as described in *Power*, Apr. 15, the one known as Experimental Cylinder No. 4 was developed. This so-called flange cylinder, shown in Fig. 1, consisting of completely new upper and lower parts, is distinguished by the joining of the inner cylinder wall and the jacket wall by a horizontal stiffening wall encircling the upper half of the cylinder just below the scavenging-valve openings and encircling the lower half just above this point. It was intended that the force that formerly worked upon the valve-opening tubes alone should now be distributed over the entire cylinder circumference. The flange, being at right angles to the expansion of the cylinder walls, would offer little resistance to their free movement. Advantage was taken of its position to distribute the flow of the cooling water after it has circulated through the spiral ways in the sleeves about the inner cylinder.

The fuel-valve housing was so mounted in the casting as to permit a considerable displacement of the inner and outer walls. The exhaust ports were given a sinuous outline, and following the results of special investigation, their height was reduced as well as their area made much smaller than formerly.

The upper piston half was so designed that it could expand freely in spite of the ribs. The cooling water was directed to flow over the inner faces of the piston head at high velocity. The upper half of the piston was made of cast iron because of the wearing qualities of this metal in contact with the cylinder walls. The lower portion of the piston was a steel casting of the design in use on large gas engines.

The lower cylinder head required no alteration, having already shown its endurance. For the upper head, which had repeatedly cracked about the openings for the relief and starting valves, a change of material was provided. This head was made of a nickel-steel casting, out of the consideration that nickel steel best withstands the high pressures and high temperatures in large guns. That the time required for filling the order for this casting might not be lost, the M.A.N. undertook a cast-iron head provided with a stiffening rib joining the starting air passage and the bottom of the head, semicircular in form, its ends butting up against the starting-valve tubes. Holes were provided through these ribs for the passage of cooling water. This cylinder was put into operation May 2, 1913, and promptly proved its superiority over previous designs. From May 19 to May 24 it was possible to run a five-day endurance test with a mean load of 1,640 brake-horsepower (1,675 max.) at 117 r.p.m. After the termination of the run very fine cracks were discovered in the lower cylinder head, although the upper one was uninjured. The cracks in the lower head, however, did not proceed from the scavenge-valve openings as before, these appearing to be well protected by the flange, but sprang from the smaller injection-valve

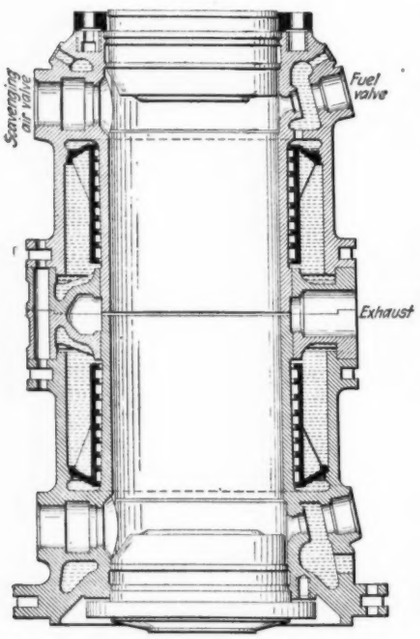


Fig. 1—Experimental cylinder No. 4

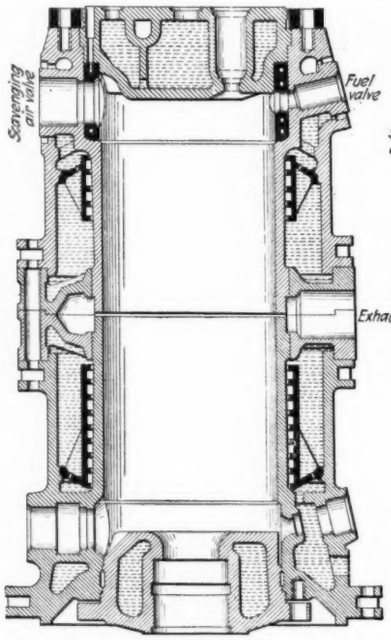


Fig. 2—New design called cylinder No. 5

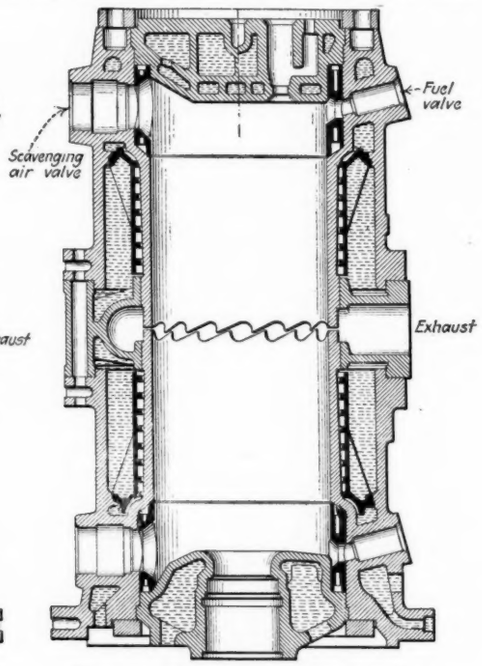


Fig. 3—Cylinder design finally adopted

*Extract of article appearing in *Zeitschrift Des Vereines Deutscher Ingenieure*, Dec. 8, 1923.

opening, which was somewhat removed from the influence of the flange.

A high load was thrown on immediately after starting until the cylinder wall temperature measured by thermo elements reached 500 deg. F., the temperature established during the endurance run. The engine was stopped then and the cylinder cooled; the temperature was quickly brought down to 104 deg. F. and the engine promptly started again and put against a high load. This operation was repeated twice in one hour. Thirty-three such trials were made with only a night's interval between trials 3 and 4 and between trials 24 and 25. Upon examination the upper half of the cylinder was still unharmed. The fine cracks in the lower half had lengthened very little. After this followed a 216-hour unbroken test at approximately 1,600 b.hp. Then a six-day test with 1,850 hp. with equally good results. As a result of this hopeful development the Marine Office sanctioned the proposal of the firm to complete the engine to six cylinders despite the fact that the goal of 2,000 hp. per cylinder had not been reached. The officials were contented with the minimum capacity specified in the agreement, a total load of six times 1,800, or 10,800 horsepower.

We reckoned that with the finished cylinder development the lower half of the cylinder would be as well protected against the development of fractures as the upper side of the present cylinder appeared to be, it being in good condition after 620 hours of operation.

During this labor of completion the search for a cylinder form that would permit of full load of 2,000 hp. went forward. Out of this development came test cylinder No. 5, shown in Fig. 2.

Final Design of Cylinder

At first only the upper half was worked out, and for the first time the principle of intensive cooling of the combustion spaces, thereby divorcing the heat and strain stresses, was employed. Since the cooling ring was freely inserted and required to carry no strains, it could be made very thin-walled and thereby thoroughly cooled. An annular wall served to stiffen the construction, and openings through it guided the water against the valve tubes. The piston face was developed into a slightly spherical or bumped profile with thin walls (1.57 in. thick), the upper half being made of cast steel following the reconstructed lower half. The upper cylinder head was again made of cast iron, but improved in so far as the holes in the vertical inner ribs forced the water to follow a tortuous path so that it was forced to pass over all dangerous surfaces at high velocity. After casting, the material was carefully annealed.

Test Cylinder No. 5 was put in operation on Oct. 11, 1913, and was heavily loaded from the start. The upper head was the first part to show fractures, then after 502 hours of operation the cast-iron cooling ring cracked. The hard water from the Nürnberg mains had deposited a crust of scale $\frac{3}{16}$ in. thick on the inner surface of the very restricted cooling space thus greatly reducing the conductivity. The means of avoiding this evil was to allow distilled water to flow through the cooling ring; this required the addition of a cooler installation to the experimental engine. Upon resuming the tests, a forged iron ring was used, the cooling water channels in which were worked out of the solid. With the employment of this construction the cooling ring never again developed cracks.

Meanwhile, in the middle of February, 1914, the completed six-cylinder engine was put into operation, with cylinders after the pattern of experimental cylinder No. 4, which in no wise corresponded to expectations. Cracks soon developed in two lower cylinder halves, proceeding from the valve openings. Spare cylinders were fitted, and it was sought to protect the parts inclosing the combustion space with a thick coat of copper put on by the Schoop metal-spraying process. This was adopted on the theory that probably the entrance of the gases of combustion into the pores of the cast iron was mainly to blame for the production of cracks. This measure also proved useless. New fractures appeared, and after 54 hours of operation the six-cylinder engine was given up as without prospect.

All Difficulties Finally Overcome

After the fitting of a cooling ring to the under side, the tests with cylinder No. 5 were prosecuted with double zeal. These experiments were much delayed by the influence of the World War, which had broken out in the meantime. The cooling rings proved excellent although corrosion and pitting, as a result of the generation of sulphurous acid out of the sulphur content of the fuel oil, appeared on the back walls of the rings where they were always cold, a condition that was successfully combated by coating the backs of the rings with lead. Neither was the cylinder free from objection, as it acquired a multitude of hair cracks proceeding from the edge of the cooling ring. The temperature measurements showed how quickly the wall temperatures fell off toward the middle of the cylinder, so the remedy was clear. The cooling ring for the upper side must be carried farther down and for the lower cylinder farther up.

After a newly produced cylinder of the series No. 5 had proved its worth in many hours of service under the most varied loads up to about 2,300 hp., the Marine Office sanctioned the completion of the six-cylinder engine with cylinders of the form shown in Fig. 3. They differ from the experimental cylinder No. 5 by only a few noteworthy changes.

The cooling-water spaces of the cooling rings were turned out of the solid forging and stopped off with screwed plugs. The upper head was provided with an intermediate wall between which and the lower side the cooling water flowed through comparatively small areas with high velocity. In the under head the flow was limited by ribs so arranged as to allow a narrow space between the ribs and the wall next to the combustion space for intensive cooling of the surface.

Cooling rings, piston and upper head were cooled with distilled water, the lower head and cylinder with the water from the mains in place of sea water which would be used on board ship. The material for the pistons and heads for the purpose of experiment was various. Three of the pistons ordered before the war were of cast nickel steel, the other three were of common cast steel. Two upper cylinder heads were of cast steel, while the four remaining upper heads and all six lower heads were of cast iron. It might be noted here that a difference in the service of these different materials could not be established as they all withstood the very hard acceptance test equally well. In general the completed development of the six-cylinder engine did not differ greatly from the earlier three-cylinder engine. The scavenge pump was driven

by the main engine, but had three double-acting cylinders, having acquired an entirely different appearance and reached complete reliability. For the production of the injection air and the air for maneuvering, two newly built compressors are now available, for the driving of each of which were provided two single-acting two-cycle engines of the Nürnberg step-piston model.

The six-cylinder engine was ready for operation in January, 1917. After overcoming a few errors in workmanship which evidenced themselves in the first trial runs, the beginning of the test may properly date from Feb. 3, 1917, on which day a 2½-hour run with a light load was carried out merely to try out the operation of the installation. This was followed by a series of tests at various loads.

The important values given in the accompanying table were determined as results of the five-day endurance test:

LOADS AND FUEL CONSUMPTION FOR THE RUNS FROM FEB. 26 TO MARCH 24, 1917

Nominal Load, Hp.	R.p.m.	B.Hp.	I.Hp.	Mech. Eff.	M.E.P. Lb. per Sq.In.	Fuel Consumption per B.Hp.-Hr. Exclusive of Compressors: Pit Coal Tar Oil, Lb.	Exclusive of Compressors: Paraffin Oil, Lb.	Including Compressors: Pit Coal Tar Oil, Lb.	Including Compressors: Paraffin Oil, Lb.
1,500	73	1,485	2,813	0.528	36.3	0.346	0.276	0.346	0.452
6,000	116	6,160	8,868	0.695	72.7	0.425	0.107	0.425	0.171
7,000	123	7,055	10,058	0.702	77.2	0.452	0.098	0.452	0.161
8,000	125	8,072	10,955	0.736	83.4	0.427	0.083	0.427	0.145
8,500	127	8,519	11,399	0.748	84.7	0.438	0.082	0.438	0.141
9,000	127	9,052	11,848	0.765	88.0	0.443	0.079	0.443	0.137
10,000	128	10,063	13,221	0.176	97.4	0.458	0.074	0.458	0.124
10,800	130	10,880	13,915	0.78	100.9	0.467	0.067	0.467	0.116
11,500	132	11,548	14,421	0.80	103.9	0.476	0.063	0.476	0.109
11,500*	132	11,610	14,358	0.81	103.2	0.456	0.063	0.456	0.110
12,000*	135	12,160	15,471	0.786	107.9	0.472	0.064	0.472	0.111

* With five scavenge pump units.

In later tests it was shown that so high a percentage of ignition oil as employed throughout these tests, was unnecessary, that 2 per cent of ignition oil would suffice. Furthermore, the fuel consumption, from the modern viewpoint, appearing rather high, was the result both of the bad quality of the oil and of the intensive cooling of the cooling rings.

The development was not at an end with the acceptance test. In the process of further tests still further improvements were made. Especially was the air consumption in starting and maneuvering greatly reduced by altering the valve-gear mechanism. As it was important to know the maximum load that this cylinder was capable of carrying without cracking or other damage, the single-cylinder engine with a cylinder like No. 5 was subjected to prolonged operation with rising load. We reached 3,218 b.hp., approximately 3,573 i.hp., at 145 r.p.m. The mean indicated pressure reached the astonishingly high value for a two-stroke-cycle engine of 140 lb. per sq.in., although the engine smoked badly. Feeding more fuel oil to the cylinder resulted in no increase of power above this, only more smoke and a slight falling off of power with still higher exhaust temperature (about 1,450 deg. F.) and higher temperature of the jacket overflow (167 deg. from 77 deg. at inlet). In spite of these tests the engine was not injured in any part. It served later to supply the works and the city system with electric power and operated at nearly full load ten hours a day without accident of any nature. The safety of the outfit and the durability of the cylinder, cylinder head and piston construction were established beyond a doubt.

In spite of all this one would build an engine of such size otherwise today. Port scavenging it would seem has reached a degree of perfection that should permit its successful application, although the scavenge valves of the engine never caused any difficulty aside from burning away of the valve heads, which could have been avoided by changing the direction of the spray. Progress with airless injection of fuel indicates in conjunction with this the road to the construction of Diesel cylinders completely valveless except for relief and starting valves, whereby costly means of protecting valve openings such as the cooling rings would not be required and the accustomed efficiencies of good Diesel engines of the day might be equaled. However, these considerations do not detract from the value of the development work on this engine, which established the practicability of engines of such size aside from much valuable experience acquired by the builders.

How Shall Compressors Be Compared?

There seem to be two schools of thought among engineers when the question of testing air compressors is brought up. One set claims that the ideal compressor by which the performance of actual machines should be compared, is one having no clearance and compressing the charge without losing heat to the cylinder walls—that is, adiabatically. The second group feels that compression in the ideal no-clearance machine should be isothermal, by which the heat equivalent of the work done is removed continuously during compression, so that the discharge temperature would be the same as the suction temperature and the heat content of the air would be constant.

In a steam engine or in any machine converting heat into work, the most efficient cycle between any two temperature levels is that one in which the heat is added at

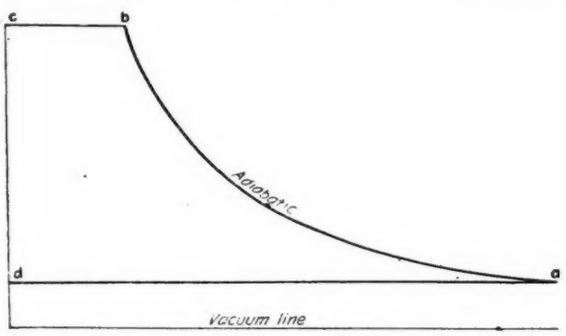


Fig. 1—Work diagram of no-clearance adiabatic compressor

the highest temperature, expanded adiabatically and rejected at the lowest temperature, followed by adiabatic compression of the working medium to the highest temperature. Since this, the Carnot cycle, is the most efficient possible to obtain in an engine, it is claimed that the cycle outlined but reversed should be used as the standard comparison for air compressors.

An indicator diagram of a non-clearance compressor operating with adiabatic compression would be similar to Fig. 1. The volume of free air drawn into the cylinder is represented by the length *da*.

Suppose that during compression a small amount of

heat be lost to the cylinder walls. The compression line is now under the adiabatic as shown by the broken line in Fig. 2, and the diagram area less than with ideal compression even though the volume of free air handled be the same. Consequently, we have the seeming paradox of a working compressor not only attaining the ideal but actually surpassing it, for the comparative compressor efficiency is inversely as the areas of the two diagrams, which represent to some scale the work of compression and expulsion.

Now how can this absurdity be explained? The fact is that the compression of air is not a complete cycle. As far as the compressor installation and efficiency are concerned, it does not matter what is done with the air after expulsion; neither is the air after expanding in

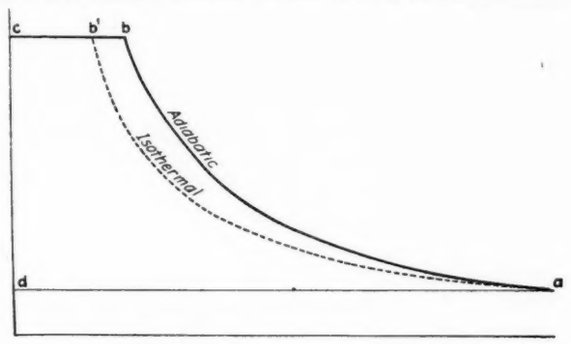


Fig. 2—Work decreased due to heat loss to cylinder walls

an engine returned to the compressor suction; in fact, the engine exhaust temperature, if the air be used in an engine, is far below the compressor suction temperature, the latter being that of the atmosphere. Upon entering the receiver it rapidly throws off at a falling temperature that part of its heat due to the work of compression and soon assumes a temperature closely approximating atmospheric and when the air reaches the air machine it is at room temperature.

Since we are interested only in raising a given weight of air from a low to a high pressure, then there should be every effort to make the compression as inexpensive in power consumption as possible. If the heat in the discharge air is of no interest, there is no advantage in conserving heat during compression. If the desirable thing is to have air at room temperature entering the air drill, then, if the removal of any part of the heat will reduce the compressor work, this removal should be carried out. If the cylinder walls were able to receive the heat equivalent of the work of compression during compression, the temperature of the air charge would remain constant at suction temperature. Compression would then be isothermal and the compression curve would coincide with the PV = constant curve.

If it is desirable to have the discharge air as hot as possible, isothermal compression followed by reheating in a fired receiver or heater would be more efficient than adiabatic compression, since the efficiency of the heater should be at least 60 per cent, while the efficiency of the compressor and driving engine would be less than 20 per cent.

It is evident that while an actual compressor never attains isothermal compression, this should be the standard by which the efficiency of the machine is to be judged.

The area of a no-clearance diagram with isothermal compression is proportional to the work done in compressing and expelling the air from the cylinder. This work may be found by the equation,

$$\text{Work} = 144\ P_s\ V_s\ \log_e \frac{P_d}{P_s}$$

where P_s = Suction pressure, pounds per square inch absolute;
P_d = Discharge;
V_s = Suction volume in cubic feet;
V_d = Discharge volume, in cubic feet;
$\log_e$ = Hyperbolic logarithm of the pressure ratio.

If one cubic foot of air be compressed, the work is equal to

$$W = 144\ P_s\ \log_e \frac{P_d}{P_s}$$

The m.e.p. per cubic foot of free air handled by the compressor is also $P_s \log_e \frac{P_d}{P_s}$ since it is work divided by stroke volume multiplied by 144.

In comparing an actual compressor with this ideal isothermal-compression no-clearance machine, the degree of efficiency of the actual machine is indicated by the ratio of the work required by the ideal machine to the work actually required to compress a cubic foot of free air. This can be put in the form of an equation

$$E_c = \frac{\textit{Work, ideal per cu.ft. of piston displacement}}{\textit{Work, actual per cu.ft. of piston displacement}}, \text{ or}$$

$$E_c = \frac{144\ P_s\ \log_e \frac{P_d}{P_s}}{\textit{Work, actual per cu.ft.}}$$

It should be observed that the work in the actual machine should be measured on the basis of work *per cubic foot of free air compressed* and not per cubic foot of piston displacement. In a no-clearance compressor these two are identical, but in a machine with clearance (and all machines have some clearance) the air trapped in the clearance space when the piston reaches the end of its compression and expulsion stroke re-expands when the piston starts on the return or suction stroke. The suction valve will not open until the pressure of

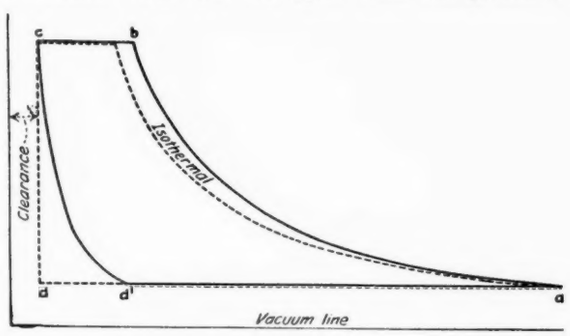


Fig. 3—Diagram from a compressor with clearance

this clearance air drops to the suction line pressure. The diagram of the clearance compressor will be similar to Fig. 3. The amount of air taken in is then ad' and not ad as in the case of no clearance. If the stroke volume ad be 1 cu.ft., the work per cubic foot of stroke volume would be represented by the diagram area, or putting it in equation form, Work per cubic foot piston displacement $= \frac{area}{ad}$, while the work per cubic foot of free air handled $= \frac{area}{ad'}$.

Since the m.e.p. is proportionate to the area ÷ length (ad), or work = 144 m.e.p. (ad), the work per cubic foot of free air is 144 m.e.p. $\left(\frac{ad}{ad'}\right)$

Since $\frac{ad'}{ad}$ is the volumetric efficiency, work = $\frac{144 \text{ m.e.p., actual}}{E_v}$, when E_v is the volumetric efficiency.

The efficiency compared to the no-clearance isothermal compressor is then

$$E_c = E_v \frac{P_s \log_e \frac{P_d}{P_s}}{M.e.p., actual}$$

Turning now to compound compression, if adiabatic compression and intercooling back to the initial temperature be taken as a standard, the work required by the ideal compressor varies with the number of stages. The formula for a multi-stage adiabatic compressor is

$$Work = 144 \times \frac{n}{n-1} P_s V_s \left[\frac{P_d}{P_s}\right]^{\frac{n}{x(n-1)}} - 1,$$

where x is the number of stages, the assumption being made that the most advantageous intercooler pressures are used. Now it would seem that the ideal machine should require an unvarying amount of work to compress and expel a cubic foot of air when operating between two given pressures. In this way the net advantage of more or less numbers of stages and perfection of intercooling would be ascertainable through comparison with the ideal machine.

This is another argument for the isothermal standard which may indeed be looked upon as a machine made up of an indefinite number of stages and intercoolers by which the air is cooled back to the initial temperature after but an infinitesimal increase in temperature.

In comparing a multi-stage machine with the ideal isothermal machine, the mean effective pressure to be used in the equation is the sum of all the m.e.p. referred to the low-pressure cylinder.

In centrifugal or turbo blowers there is no reason to use any other standard. True, the turbo blower does have an almost adiabatic compression in the stages; in fact, it is quite possible to find the discharge temperature above that due to adiabatic compression, since eddy currents and blade friction may add heat to the air. But this merely indicates the disadvantage of the particular machine.

As long as air is stored in receivers and reaches room temperature before being used, there is little if any reason for engineers making use of any but the isothermal standard.

Wet Ammonia Compression Is Best

From tests that have been made it has been proved that the dry compression is the more efficient. One reason for this is that the average operator of a wet-compression machine will operate his machine too wet. He either injects too much liquid at the compressor, or brings the gas back from the ice tanks or coils too heavily saturated, with the result that he gets re-expansion in the cylinder, which reduces the capacity of the machine.

There is just as much fault in operation from bringing the gas back to the compressor superheated or supersaturated. The results are just as detrimental to the capacity of the compressor as the increase in volume due to the superheat is very large. As an example, 20-deg. superheat in the suction gas reduces the capacity of the compressor 5 per cent. The influence of clearance in compressors is not so detrimental to efficiency as has been claimed. It is, however, very detrimental to the capacity of the compressor and the more so the greater the difference between the high and low pressures.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

115. When crown sheets of locomotive boilers are patched, why is it customary to place the patch on the inside?

The placing of the patch on the outside would leave a considerable area for collection of sediment, which would, in turn, cause the patch to become overheated.

116. Why do not locomotive crown bars rest directly on the crown sheet?

It is not desirable that the crown bar should rest directly on the crown sheet for the reason that such an arrangement provides too considerable an area of unwetted crown-sheet surface.

117. Staybolts in water legs break near the outer end more often than near the inner end. Why?

The furnace sheet, supported by the inner end of the staybolts, moves about to a greater extent than the sheet supported by the outer end. Hence, the combined strains tending to break the staybolt are concentrated nearer the outer than the inner end, with the result that breakage is more likely to occur near the outer end.

118. A water-tube boiler built for 200 lb. pressure has 30 sq.ft. of grate surface. This boiler is equipped with a safety valve having an area of 9.7 sq.in. A return-tubular boiler operating on the same header is built for 125 lb. pressure, has 28 sq.ft. of grate surface and is equipped with a safety valve having an area of 12.6 sq.in. Both safety valves are set at 90 lb. What objectionable feature is suggested?

The objectionable feature is the inadequate area of the safety valve on the water-tube boiler. This valve at 90 lb. gage pressure will discharge a maximum of 4,600 lb. of steam per hour, while the grate area is sufficient for the evaporation of over 7,000 lb. of water per hour. Therefore, although the safety-valve area, with the valve set at 200 lb., is sufficient to discharge the maximum generation, it is not of sufficient area, when set at 90 lb., to discharge the maximum generation of steam.

119. How would one determine whether fire cracks in a girth seam of a fire-tube boiler constituted a condition dangerous enough to warrant patching or the installation of a new sheet?

If fire cracks extend circumferentially from rivet to rivet, in two or more places on the same seam, a new sheet should be installed. If the cracks extend longitudinally from the outer edge of the rivet hole to the edge of the plate, and there are no leaks, they may be arc welded provided they are not directly exposed to the furnace gases. If they are so exposed and the boiler is over ten years of age, a new sheet should be installed. If the boiler is less than ten years old, no repair will be necessary until leaks develop, when a new sheet should be installed. If a single crack extends longitudinally from the inner edge of the rivet hole, a new sheet should be installed.

Water Treatment at Cahokia*

By E. H. TENNEY†
Chief Engineer of Power Plants, Union Electric Light & Power Company

THE supply of water for the various requirements of Cahokia Station must almost of necessity be from the Mississippi River. Aside from the large quantity for condenser cooling purposes, the amount necessary for other uses, such as boiler-feed makeup water, cooling water for jackets and transformers, for ash sluicing and fire service, for drinking and toilet service, amount to a quantity which for the most part cannot be used in the raw condition in which it is found in the river.

The boiler-feed makeup water is supplied from a two-effect Lillie evaporator, which receives its water supply from what is known as "treated" water, by which is meant river water from which both the suspended and dissolved solids have been largely removed. Water for jacket and transformer cooling and for toilet purposes is what is known as "semi-treated" water, by which is meant river water from which suspended solids have been removed and dissolved solids except the soluble sulphates. For the sluicing of ashes and general fire purposes raw river water is used, and for drinking purposes semi-treated water which has been chlorinated.

In order to indicate the necessity for treating and softening this Mississippi River water, even for its use in evaporators, it is necessary to point out some of the characteristics of this water which in its untreated condition has many undesirable qualities. This water frequently contains as high as 35 grains per gallon of scale-forming substances; it has a high turbidity, the suspended matter often amounting to 350 grains per gallon. It is of comparatively high alkalinity, and during certain seasons of the year, especially the late summer months, when the suspended solids contain large quantities of organic matter, there is a scum-forming element in the water which tends to volatilize readily under high temperatures and is very undesirable and may be detrimental in boilers or evaporators.

For the various uses at Cahokia it was decided to treat the raw river water by the use of chemicals and settling basins to eliminate these objectionable qualities, and supply water for general use that would result in a minimum amount of corrosion or scaling, and for boiler-feed makeup a highly softened water that would leave a minimum of residue in the evaporators. In the first section of the plant, therefore, a system has been installed that is of sufficient capacity to take care of the requirements of the entire station, when extended to its full capacity of 300,000 kw., supplying both the so-called semi-treated water for general use and the more fully softened water for evaporators.

On account of the constantly varying quantities of impurities in this water it is not possible to prescribe any definite and fixed formula for its treatment that would make it suitable for use in boilers or evaporators, hence a general scheme of treatment must be used which can be adjusted at any time and at short notice to meet each change of condition of the river water. Treatment of the raw water is accomplished in a series of settling basins arranged as outlined in Fig. 1, to which the water is supplied after having been thoroughly mixed with the proper charges of milk of lime, sulphate of iron, and for the final treatment, with barium hydrate. After having passed through three of the settling basins, this water, which is now semi-treated, is delivered to a compartment from which it is supplied to the so-called semi-treated water pumps. A large part of this semi-treated water, after having been used for cooling in the plant, is returned at a higher temperature to the fourth settling basin after having been thoroughly mixed with the proper charge of barium hydrate. After passing through the fourth and fifth basins, this water, which is now fully treated, is first passed through a bed of fine excelsior and thence is delivered to the four storage basins, from which the water is available for use in the evaporators.

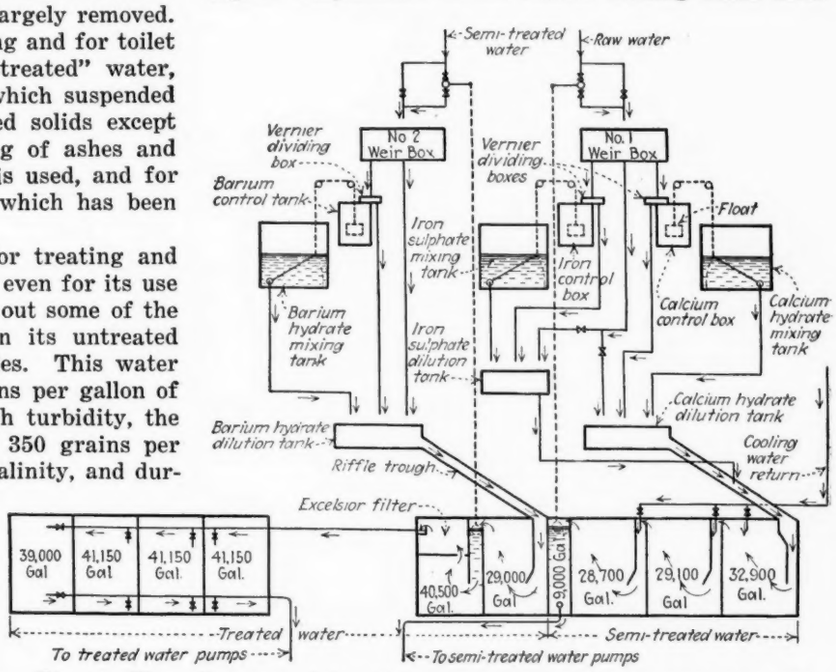


Fig. 1—Flow diagram of treating systems, showing arrangement of chemical mixing and dilution tanks

The alkalinity of the raw Mississippi River water, by which is meant the amounts of the carbonates of lime and magnesia that it contains, varies with the seasons and the quantity of water flowing; that is, the stage of the river. The amount of mineral matter dissolved by the water as it passes over the beds of the creeks and river will depend on the amount of the carbon dioxide that the water contains. During the warm months decaying vegetation is constantly supplying large amounts of carbon dioxide, which is the product of animal and vegetable life. This in turn, dissolved by the rains, unites chemically with the carbonates of the minerals as they lie along the beds of

*A general description of the Cahokia station of the Union Electric Light & Power Co. appeared in the April 1 issue.

the rivers, forming the soluble bicarbonates. Also, the actual number of grains per gallon of these substances will vary with the amount of water that is flowing. With the river at the 20-ft. stage the solutions will be much less concentrated than at the 10-ft. stage, and the alkalinity of the water will be lower.

The reactions taking place between these soluble bicarbonates and the milk of lime with which the water is treated is represented by reactions 1 and 2 thus:

$$CaH_2(CO_3)2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O \quad (1)$$

$$MgH_2(CO_3)2 + 2Ca(OH)_2 = Mg(OH)_2 + 2CaCO_3 + 2H_2O \quad (2)$$

A certain amount of free carbon dioxide is also in the water which reacts with the lime as in reaction No. 3:

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O \quad (3)$$

thus the smaller the amount of bicarbonates in the raw water the less will be the amount of lime necessary.

The resulting normal carbonate of lime ($CaCO_3$) is only slightly soluble in water and precipitates out readily in the settling basins, carrying down with it to a greater or less degree the suspended matter.

The turbidity, by which is indicated the amount of suspended matter in the water, is a variable quantity. When the water supply is taken from near the banks of the river the turbidity will be found to be much higher than that of the water in midstream. During the winter months, too, when the ground is frozen, the turbidity of the water is much lower than at other seasons of the year. Were the turbidity low enough, say 200 parts per million, the precipitation from the reaction between the milk of lime and bicarbonates in the water would be sufficient to clarify the water without the use of sulphate of iron, in which case the iron is omitted from the treatment. However, when the suspended matter is high and a large part of it organic, as is sometimes the case, the flocculent precipitate from the ferric hydrate is necessary to a satisfactory coagulation and sedimentation.

All the major impurities in the raw water are reduced by the treatment with lime and iron except any sulphate of lime that may be present. This is slightly increased as shown in reaction No. 4:

$$FeSO_4 + CaH_2(CO_3)_2 = FeH_2(CO_3)_2 + CaSO_4 \quad (4)$$

This sulphate of lime ($CaSO_4$) is then combined with its proper amount of barium hydrate and reacts as in equation 5:

$$CaSO_4 + Ba(OH)_2 = BaSO_4 + Ca(OH)_2 \quad (5)$$

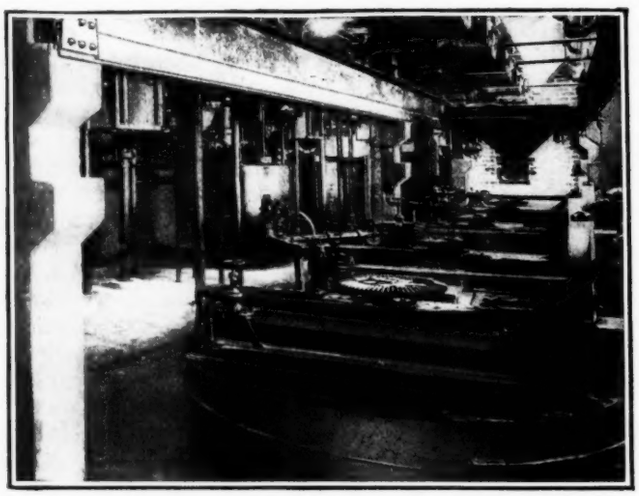


Fig. 2—Arrangement of chemical mixing tanks

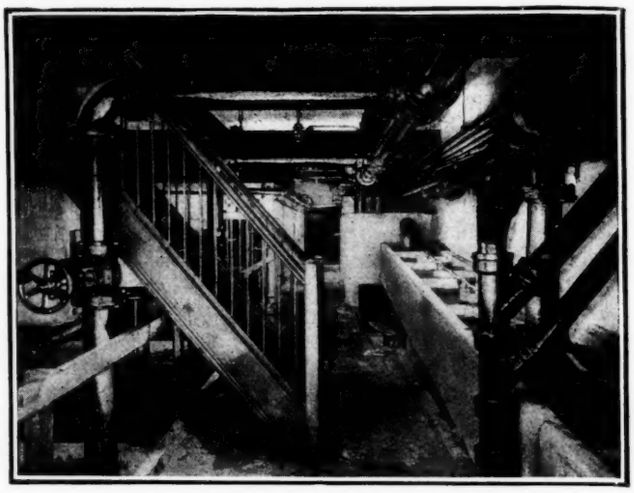


Fig. 3—Dilution tanks and riffle trough

the barium sulphate for the most part going through and being deposited in the evaporators.

The bicarbonate of iron in equation (4) is acted upon by the lime as in equation (6):

$$FeH_2(CO_3)_2 + 2Ca(OH)_2 = Fe(OH)_2 + 2CaCO_3 + 2H_2O \quad (6)$$

and the ferrous hydrate—$Fe(OH)_2$—combining with water and oxygen becomes ferric hydrate as in equation (7):

$$2Fe(OH)_2 + H_2O + O = Fe_2(OH)_6 \quad (7)$$

which forms a flocculent precipitate. The carbonate of lime liberated in the later reactions is taken up by the excelsior filter. The charge of sulphate of iron varies throughout the year from zero to 3.5 grains per gallon.

The color of the raw untreated water gives a fair indication of the amounts of organic matter in solution, and although the color varies somewhat widely with the changes of season, it is not a large factor in determining the necessary charges of chemicals.

In Fig. 1 are outlined various points at which the chemicals are automatically apportioned to the water, and Fig. 2 shows the arrangement of chemical mixing tanks, with the weir tanks at the left for apportioning the proper amount of chemicals to the raw water. The chemical charging equipment is standard equipment of the Graver Corporation. In the photograph the chemical storage bins may be seen directly above the various chemical mixing tanks. From these storage bins the chemicals are weighed in the traveling hopper, from which they are dropped directly into the mixing tanks. The strength of solutions in the chemical mixing tanks are determined each day in accordance with the particular chemical content of the raw river water. This solution is maintained at uniform strength by mechanical agitation and is fed into the raw water in accordance with the quantity of raw water flowing.

In the photograph, Fig. 3, are shown the diluting tanks and sluiceway in which the raw water and chemicals are intimately mixed before being delivered to the first of the series of settling basins.

The impurities deposited from this system of clarification and softening are of a quantity that requires their removal at frequent intervals from the bottom of the first two basins, which is accomplished by means of centrifugal pumps whose suctions are connected to headers connected directly to the basin hopper bottoms.

The Most Desirable Percentage of CO_2

MOST engineers realize that the chief loss in a boiler installation is that due to the sensible heat of the dry flue gases, although some other losses, such as those due to combustible in the ash and to radiation, must be given serious consideration. It is also generally appreciated that the sensible-heat loss in the flue gas decreases as the CO_2 goes up, not only on account of the reduced total weight of flue gases, but also because of a lowered flue temperature. In general the engineer strives to maintain as high a CO_2 as possible, keeping in mind, however, that the percentage obtainable with economy is limited by the possibility of CO formation and of damage to the refractories.

This knowledge, good as far as it goes, is insufficient for the operation of a boiler plant on a truly scientific basis. At the very start the question arises as to how much CO can be permitted to form before the increase in combustible gas will offset the decrease in the sensible-heat loss. Again, allowance must be made for the decreased consumption of power by the forced-draft fans as the percentage of CO_2 is increased. There is still another important matter almost always neglected in discussions of this sort. That is the fact that the net gain in boiler efficiency from increased CO_2 is partly offset by a lower thermal efficiency of the turbine. This arises from the reduction in superheat that always accompanies increased CO_2 with ordinary types and locations of superheater.

The best percentage of CO_2 to carry in any given plant is that corresponding to the minimum cost per kilowatt-hour for energy delivered by the station, when all these factors are considered. In this matter each plant is a law unto itself. Because 14 per cent of CO_2 is best in one plant, it by no means follows that it is best in another with different apparatus and different operating conditions. The scientific method of procedure is to make a series of tests in the given plant which will give sufficient data for figuring this most desirable percentage of CO_2. While these tests will take some time and must be made with care, they need not necessarily involve the difficulties that go with an actual evaporation test where coal and water must be accurately measured. A determination of those losses only that vary with the percentage of CO_2 should be sufficient.

An excellent example of such an analysis for one plant is to be found in an article on page 634 of this issue. The tests were made at the Connors Creek plant of the Detroit Edison Co., which has been the scene of much scientific study of operating conditions. While the numerical conclusions given cannot, for obvious reasons, be appiled directly to another plant, the method of attacking the problem can be adopted practically without change and with worth-while results.

Importance of Operating Data in Hydro-Electric Plant Operation

TWO things, input and output, are essential to the efficient operation of any power plant, whether it be steam or water power. There are many other factors that enter into an intelligent and comprehensive undertsanding of operation, all of which may contribute toward efficient operation, but a final check on the excellence of plant performance over a given period can be obtained only by knowing the input and output.

Within recent years operators of steam plants have been giving careful attention to measuring the input or fuel consumption, so that a careful check can be made on each operating shift and any defects causing a falling off in efficiency corrected. In hydro-electric plants conditions have not in general been so fortunate. The switchboard in such plants may be equipped with devices for measuring and recording the output, and little or no attention given to the input of the plant. In fact, not infrequently the machines have been put into service without running an efficiency test on them to determine the best loading of the units. A case in point is that of a plant that had been in operation for over a year before such tests were made, when it was found that the machines developed very little more power at full gate than at eighty-five per cent gate. After these tests were made, the turbines were never operated beyond the latter point, with the result that the output of the plant was increased twenty per cent.

When tests are made, curves should be worked up to show the operator the best loading on the turbines, and if no other method is available the turbine gates should be calibrated so that the input to the unit may be determined and a check kept on operation. After the turbine has been put into service there are many things that can occur to impair its efficiency, such as clogging of the racks, especially the bottom portions, if proper provisions have not been made to keep them clean. Conditions of the penstock's surface turbine gates, runner and draft tube, wear on operating gear and runner seals, all affect the efficiency of the turbine. Unless periodic inspections are made and operation checked by efficiency tests, the output of the plant may be seriously impaired without anyone being aware of the conditions. Fortunately, there is an increasing realization of the value of proper operating data, among hydro-electric operators, and on a number of systems careful attention is given to water-power plant operation. Coincident with this methods for measuring the water taken by medium- and high-head turbines have been developed that make this operation comparatively simple. Investigations now being conducted into using the pressure differential across the penstock valve or a change in cross-section in the penstock, as a means of obtaining a record of the input to the turbine, give promise of solving this problem in a simple manner.

One Road to Power Conservation

IF THE management of an automobile factory finds that the costs of the department working the engine are excessively high, his first thought is by no means that of abandoning the department and the purchase of the engine from an outside concern. Without exception the manager would institute a rigorous investigation as to the cause of the high costs. If the basis was found to be a matter of departmental management, a change of personnel would occur. If out-of-date machine tools were lowering output and increasing the unit costs, hurry-up orders would go out for the necessary new tools. Only as a last resort would the purchase of an outside engine be considered.

This condition is typical in many factories, with the high-cost department being the power plant. But so peculiar is the human brain that intsead of recommending revamping the power plant and discarding the worn-out units, many engineers recommend the abandonment of the plant in favor of outside current as the proper remedy. Much of the argument in favor of purchased power is based on existing plant costs and not upon a comparison of electric rates with the cost in the private plant when the latter is properly equipped and handled.

There is no gainsaying that hundreds of factory power plants could well be shut down so small is their output, but where conditions are such that the demand for exhaust steam fits in with the demand for power so that for six winter months of the year the engine room can be operated at an efficiency of ninety per cent, and where the load factor is high, real conservation calls for the continuation of such plants. There is no reason why a well-designed and efficiently operated plant of five hundred horsepower or over should not deliver a kilowatt-hour on close to three pounds of coal in summer, and many do so. In winter the coal chargeable to power need not exceed one-half pound per kilowatt. This makes the net all year around rate comparable with that prevailing in central stations. The real road to conservation lies in the junking of a lot of antiquated machinery and replacement with modern efficient units, together with the employment of a high-grade engineer.

The Separately Fired Superheater

SINCE reheating the steam between cylinders, as proposed in several of the new high-pressure stations, is essentially a re-superheating proposition, consideration of the characteristics of separately fired superheaters is in order, although the present plans for these stations call for a somewhat modified arrangement.

An outstanding characteristic of separately fired superheaters is the difficulty of regulating the degree of superheat. Many of the earlier units had furnaces with checkerwork brick walls shielding the superheater tubes. Sudden decreases of load were often handled by opening the firing doors and allowing cold air to flow over the fire and across the superheater tubes. Naturally, this decreased furnace efficiency and was hard on brickwork.

Radiant-energy superheater surfaces might be placed on all sides of the furnace, and if gas or oil were used, the operation should prove satisfactory. The fuel and furnace conditions could readily be regulated by a thermostat on the superheater outlet, and any fluctuations in steam demand could be readily met. When coal must be used on stokers, this form of superheater would appear less desirable, for there will always be a large amount of heat stored up in the burning mass of fuel and any necessary arches, which might seriously overheat the superheater should the steam flow suddenly stop.

Another proposal is to place some sections of a water-tube boiler between the furnace and the superheater tubes where coal is used. This boiler section would absorb the radiant heat of the fire and protect the superheater surfaces from this heat when no steam is flowing through the tubes. The superheater is then of the usual convection type. In order to get the high steam temperature now desired, the gases leaving the superheater surfaces must be at a high temperature, and unless additional heat absorbing surfaces in the form of more boiler tubes or economizer tubes are placed in the path of the flue gases, the net efficiency will be low. The problem of increasing steam temperatures then resolves into either an inter-deck superheater in a boiler or a complicated boiler-superheater-economizer design. The regulation of this latter unit will not be simple, for in spite of the water screen between the superheater and the fire it may still be subjected to high temperatures on sudden stoppage of flow. Any provision to increase the flow through the superheater by blowing off steam at such times means a waste of heat units.

The admission of too highly superheated steam to a turbine after a load interruption is very undesirable. Means might, therefore, be provided to insure against this contingency with separately fired superheaters.

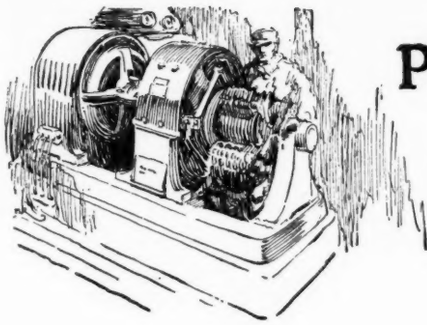
Non-Condensing Turbines Not Inefficient

THE popular idea that condensing turbines are more economical thermally than engines, while non-condensing units are distinctly less economical, is subject to far-reaching qualifications.

The unaflow type of engine ordinarily is taken as the more economical for non-condensing work. Rankine-cycle ratios of eighty per cent are attained in units as small as three hundred horsepower. On the other hand, comparatively little more efficiency is gained up to the largest engines. It seldom pays to build a small turbine with refinements necessary to give equal economy.

As sizes grow larger and steam pressures increase, commercial efficiencies of steam turbines compare more favorably with engines. In capacities of two thousand to three thousand horsepower the average condensing turbine is ordinarily taken as appreciably better than an equivalent engine. In units of six thousand to ten thousand horsepower the non-condensing engine appears to have little superiority thermally. In capacities attained by large turbines, generally speaking, non-condensing engines are not necessarily appreciably superior.

For the best possible commercial turbine performances, high-pressure stage efficiencies of large machines are quoted at eighty-two per cent and higher. In spite of the greater steam friction at high pressures it is considered possible to build high-pressure units equal in efficiency to condensing turbines. High-pressure elements at eighty per cent are not unknown. To speak of high-pressure turbines generally as inferior to steam engines in efficiency hardly states the matter fairly.



Practical Ideas *from* Practical Men

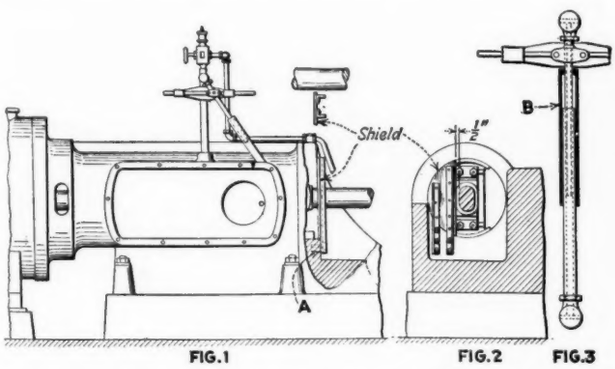
How the Loss of Oil Around the Telescope Oiler Was Eliminated

One of the engines in our plant is fitted with a stanchion post above the crosshead guides to support the crosshead-pin oiling mechanism and also the reducing motion for attaching indicator cord. For some time after installing this engine we were troubled with oil splashing through the slot in which the telescope operates to furnish the crosshead pin with oil; some splashing also took place at the top of the lower tube of the telescope.

We applied a shield around the slot about a foot high and fastened it by the side-shell capscrews, but the oil still got over this shield.

Upon examination we found that the crank would throw the oil up through the slot against the telescope, which on the return stroke would splash it over the shield. In order to remedy this trouble, we cut a semicircular piece of sheet iron and riveted it to two angle irons which were later screwed to the offset *A* in the engine frame shown in Fig. 1, leaving ½ in. space between this sheet and the connecting rod. This shield prevented the oil thrown by the crank from striking the telescope.

To stop the oil splashing from the top of the telescope, we removed it from the engine and cut a thread on the end of the sleeve, which hinges in the crosshead



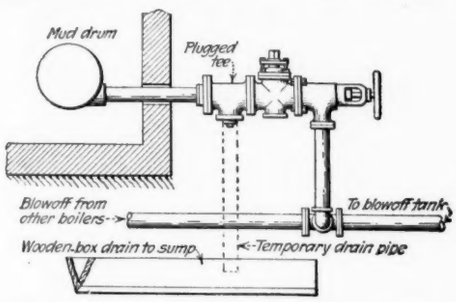
Figs 1 to 3—Detail of shield and auxiliary tube on telescope oiler

of the reducing motion, and applied another tube over the telescope suspended from the reducing motion sleeve, as shown in Fig. 3. This stopped the splashing from the telescope at that point. We had experienced some trouble at intervals with the telescope not taking sufficient oil, but have not had any trouble since this change was made. A. A. FETTE.

New Iberia, La.

Temporary Drain Facilitates Boiler Cleaning

In a plant having several water-tube boilers connected to a common blowoff pipe, water was used for driving the tube cleaner and washing out the boilers. Trouble was experienced from boiler scale getting into the blowoff tank, and in addition the blowoff pipe was too



Temporary drain provides free passage for scale and permits keeping blowoff valves closed

small to carry away the water fast enough. Also, it was sometimes necessary to blow down other boilers while men were working on the tubes in an idle boiler. To do this the tube cleaner had to be stopped and the blowoff valve closed until the other boiler had been blown down.

To obviate this difficulty, plugged tees were connected to the boiler, as shown in the sketch. When a boiler was taken out of service for cleaning, the plug was removed from the tee, a short piece of pipe screwed in its place, and the blowoff cock closed. From the end of the temporary pipe a V-shaped box drain led to the sump from which all the surface water was pumped to the sewer. A screen was placed in the drain at the sump to catch the boiler scale. In this manner the blowoff pipe and tank were kept free from scale. M. M. BROWN.

Utica, N. Y.

Casehardening Machine Parts

If it were commercially feasible to build machinery with hardened steel parts in place of those of mild steel and iron now universally used, better and more efficient service would result and much of the "laying up" of machinery would be avoided.

Where there is much machinery in daily operation, pins, studs, bolts, rollers, and slides are constantly wearing out and must be replaced. These are usually made of mild (cold-rolled) steel and are readily made in the plant machine shop. If they can be hardened when repairs are made, and before being returned to service, they will last much longer and give better results. A

satisfactory job of casehardening can be done in any shop without the use of boxes of bone and horn, etc.

Procure a quantity of cyanide-chloride mixture 73-76 per cent. This chemical is poisonous and should be kept away from the eyes and mouth. Place some of the cyanide, which is in rock form, in a substantial metal pan and heat on a forge or by some other means. The cyanide will melt and be of about the same consistency as water. Heat it to a dull red and place the pieces to be casehardened in the liquid. It is advisable to heat the pieces slightly before immersing them, so as to prevent splattering that would otherwise occur. Maintain this red heat during the time the pieces are left in the solution. The length of time the work is "cooked" will determine the depth to which the casehardening penetrates. Ten minutes of boiling for small parts is sufficient to put a surface "skin deep" on the work. Larger pieces will require more time to bring to a red heat and will consequently require a longer treatment. Remove the parts and immediately quench in cold water. The steel is now guaranteed to be file-proof. If any work must be done on the finished material, emery and oil will have to be resorted to.

It is necessary that a pan of substantial construction be used to hold the cyanide, as a thin pan will soon burn through. A cast-iron pot is satisfactory, or if a welding outfit is handy, a shallow pan can be constructed out of ¼-in. sheet steel. If many small pieces are to be treated, it is very convenient to construct a small basket of close-mesh wire to place the parts in. The basket and its contents can be lifted from the acid and cooled with one operation.

A. R. KNAPP.

Louisville, Ky.

Causes of Direct-Current Motors Overspeeding

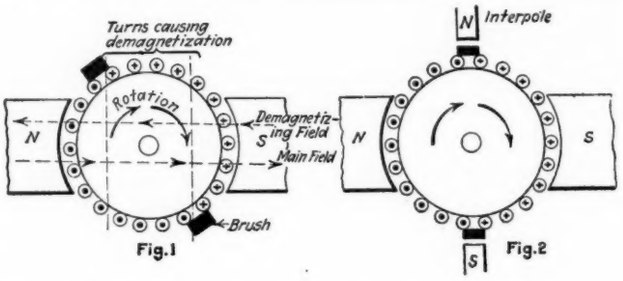
The electrical maintenance or repair man who does not have the advantages of a technical education is often confronted with problems that are quite puzzling to him, but may be readily solved by the application of a little elementary theory. Some of the most puzzling of these problems are in connection with the overspeeding of direct-current motors.

The average man who has to do with the maintenance or repair of motors probably is more or less familiar with the principles underlying their operation, which may be found in any textbook or handbook on the subject, so it is not deemed necessary to include this theory here. It may be shown, either theoretically or by practical experiment, that the speed of any motor varies almost directly with the impressed armature voltage and inversely as the magnet flux through the armature. It is possible that the overspeeding of a motor might be due to increased voltage. About the only case in which such a condition would occur in practice would be when the motor was used on other than rated voltage, as when a 110-volt motor was connected to a 220-volt line. Even this would not necessarily cause excessive speed in the case of a shunt motor, as the flux would also be increased, although not in direct proportion. It is a reduction in flux that causes most cases of over-speeding.

A reduction in flux may be the result of one of two things—a break in the field circuit or an opposition of two fields causing a differential compounding effect.

Any break in the field circuit is easily detected by simple tests, such as putting an ammeter or lamp in the field circuit. The other cause is not always so readily apparent. In its simplest form it consists of a reversed series field coil. If short-circuiting the series field with a heavy wire cures the trouble, a reversed series field is indicated, and the remedy is obvious. If a cumulative-compound generator is used as a motor without reversing the series-field connection, it will be differential compounded, with undesirable and sometimes disastrous speed characteristics.

Armature reaction is the other cause of field weakening. Fig. 1 illustrates the effect of armature reaction. In order to avoid sparking at the brushes, it is necessary to place the armature conductors that are undergoing commutation, in a field of such direction and strength as to bring the current in the short-circuited coils to zero. In a non-interpole machine this is accomplished by shifting the brushes so that the conductors are under the tip of the pole they are about to leave. It will be



Figs. 1 and 2—Show location of brushes on non-interpole and interpole motors

seen that the conductors inclosed in the dashed lines comprise a coil that tends to send flux in the opposite direction to the main field flux. The armature current that flows in these conductors, and therefore the opposition to the main flux, will increase with the load and cause the differential compounding effect. If the brushes are shifted only enough to insure sparkless operation, this field will be so weak compared with the main field that its effect will be more than neutralized by the greater resistance drop in the armature at heavy loads. However, if the brushes are shifted too far, this effect may be serious. I have seen motors that would run at normal speed at no load, but would speed up to about four times normal at half-load. There was also a tendency to "hunt" excessively, drawing a current four or five times normal during the speeding up and actually feeding current back into the line during the deceleration periods. Shifting the brushes back to the normal position completely eliminated the trouble.

In modern motors interpoles are used to supply the commutating field. The brushes are then set in the neutral magnetic plane, as shown in Fig. 2. If the brushes are shifted backward, the interpole flux will link with the armature conductors, but in opposite direction to the main flux. As the interpole windings are in series with the armature, a differential compounding effect will be produced. As the interpoles are very narrow, only a small displacement of the brushes may cause the interpole flux to link the armature turns, causing the effect previously noted. Interpole motors are adjusted for proper commutation, not by shifting the brushes, but by adjusting the strength of the interpole. This may be done by changing the shunt, if there is one, around the interpole or, if there is no shunt, by varying the interpole air gap. This may be done by varying the thickness of the steel shims between yoke and interpole.

Manhattan, Kan. D. R. DE TAR.

Comments from Readers

Methods of Socketing Cables

Being confronted with a very difficult problem, I would like to know if there is any method of socketing a steel hoisting cable, other than molten metal, wedges or Crosby rope clips. On account of not being able to use a blow torch in the mine, I thought probably there might be some plastic metal that could be poured into the rope socket.

J. M. NAYLOR.

Sunnyside, Utah.

Heat-Work Conversion Law

In the March 25 issue William R. Williams has a communication wherein he endeavors to show that something is wrong with the commonly accepted theory of conversion of heat into work. In his development he makes use of an ideal Otto-cycle diagram, which is reproduced herewith.

The characteristic of the line *IC* is that every point upon it represents the pressure that would result from the addition of 50 B.t.u. to the gas above a point, at the same volume, on the compression line *LJ*. In Mr. Williams' development this 50 B.t.u. was assumed to be the amount of heat rejected with the exhaust, and a total of 100 B.t.u. was supplied for each cycle. The 100 B.t.u. he conceives to be divided at the outset into two parts—the one disappearing from the gas during expansion, and the other persisting as heat in the gas to the point *C*, where it is then rejected as heat in the exhaust.

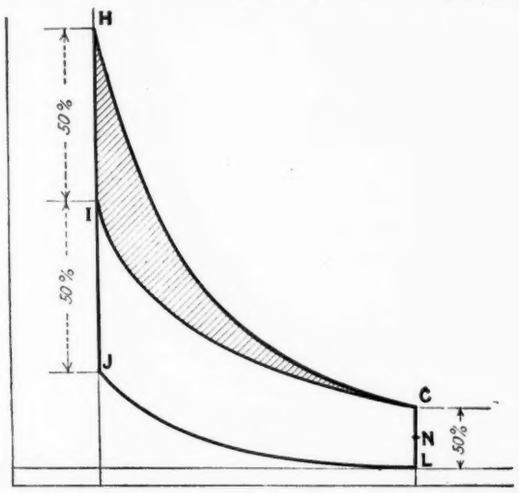
The area *LJIC* is the work attributed to the 50 B.t.u. "unconverted" heat, while the area *IHC* is credited to the other division of the original heat. It is not quite clear what the development is intended to prove, but it seems probable that its purpose may be to show that low-temperature heat is more efficiently applied than is high-temperature heat, in the production of mechanical work.

It should be apparent that if these "unconverted" heat units, starting in at *I*, are to maintain the gas at the state represented by *IC*, doing the work *LJIC*, and still exist as heat at *C*, they must have assistance. If they have not, then the path from *I* will be along an adiabatic to *N*, and the work done will be *LJIN*. Help must come from some source if the additional work *NIC* is done, and the gas is released at the higher pressure *C*.

But since the expansion line *HC* is specified as an adiabatic, the possibility of heat assistance coming from some source external to the gas, is at once precluded. Hence assistance can come only from the so-called "converted heat," which must therefore be credited, not only with the work represented by the shaded area *CIH*, as Mr. Williams has done, but also with the area *CIN*. Thus the "unconverted" or low-temperature heat is to be credited with the area *LJIN*, and the "converted" or high temperature heat, with the area *NIHC;* and if these heat quantities are equal, as was assumed in Mr. Williams' example, the areas representing work credited to each are equal also.

Ann Arbor, Mich. J. E. EMSWILER.

Referring to the letter "Heat-Work Conversion Law Questioned" in the March 24 issue, I note that Mr. Williams desired to be answered without equivocation. In that case he must restate his proposition, applying the same condition to himself. The fallacy of his reasoning is based on designating a certain area *LJICL* (see his illustration reproduced here for reference) as the work *done* by an *unconverted* portion of heat. He has failed to recognize that all the work has been done at the expense of that part of the heat that has disappeared. The unconverted portion has been unchanged by the work accomplished, but remains at the end of the process either as a waste product or as a form of potential energy which could in turn be converted to more work *if* the conditions were favorable.



Ideal engine diagram reproduced from Mr. Williams' original letter

A simple analogy may show this more clearly. Suppose a man were to set out on a journey, representing something to be accomplished, with $100 in his pocket corresponding to the 100 heat units supplied along the line *JH*. He travels, say, 50 miles at a dollar a mile and then meets with the misfortune of being robbed of the balance left in his pocketbook. The fifty miles that he did cover were clearly at the expense of the fifty dollars actually expended, and the sum taken from him was certainly unchanged. Had he not been robbed, he could have continued for another fifty miles, so it constituted a possibility of further accomplishment, just like the heat in the cylinder at the end of the working stroke.

The proof of his contention is ingenious but false. He argues that the unconverted heat has done some work in that by its presence it has maintained the pressure that did a portion of the work. If this were

so, we should have heat doing work and still remaining intact as heat. As a matter of fact, *all* the heat existing in the medium at any point enables it to exert pressure and so do work against a moving piston, with a consequent sacrifice of *some* of that heat. It is the failure to comprehend the distinction between "work done by" and "work done at the expense of" that leads the contributor to the conclusions so directly contradictory to those commonly accepted.

Worcester, Mass. CARROLL F. MERRIAM.

With reference to Mr. Williams' letter I submit the following: Starting with the fundamental relation

$$Work = pressure \times change\ in\ volume$$

we have, if the pressure is variable:

$$Work = m.e.p. \times V$$

Hence, for the cycle in question, the work is equal to the area *JHCLJ*.

By hypothesis the amount of heat converted is 50 B.t.u.—therefore, the Thermodynamic Law attacked by Mr. Williams demands heat, in foot-pounds, equal to $50 \times 778 = JHCLJ$, where 778 is the mechanical equivalent of heat. So much for the 50 B.t.u. converted.

The rejected 50 B.t.u. cannot be represented on the cyclic diagram for the reason that no cycle is 100 per cent efficient (as a cycle apart from any losses) and therefore its area cannot represent the sum of the converted and rejected energy.

Comparing the foregoing with the allocation of areas by Mr. Williams, we may prepare a table as follows:

	According to foregoing	According to Mr. Williams
Work due to 50 B.t.u. converted	Area *JHCLJ*	Area *IHCI*
Work equivalent of remaining 50 B.t.u.	Impossible to show on diagram	Area *ICLJI*

I trust this will help some to clarify the situation.

With regard to the statement about "mathematical" heat may I state that I have never heard of the expression. Moreover, heat, whether "mathematical" or otherwise, is not "simply" temperature and I am sure never has been proved to be such. JULES GUEDALIA.

New York City.

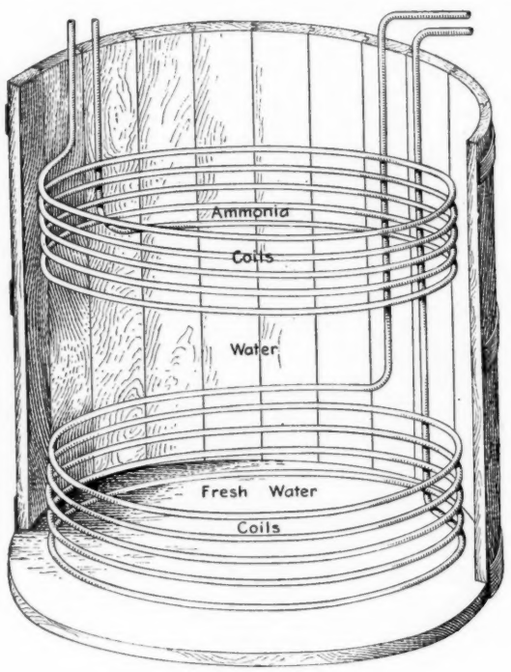
Drinking-Water Systems

I read the article by H. J. Macintire in the Feb. 12 issue of *Power*, with unusual interest and agree with most of the ideas he outlined. I consider it a mistake, however, to design a cooler as shown by his Fig. 5.

Two or three years ago a refrigerating concern in this locality installed two water coolers which were made along these lines, with a liquid ammonia coil inside. It worked beautifully for a time, but just as soon as cold weather came, the ammonia inside plus the cold weather outside made it a simple matter for the water surrounding the coil to freeze. Both coolers burst open within a few hours of each other. Ice built up around the coils until the wall of the cooler was reached, whereupon the ice expansion broke open the walls. This probably would not have happened if water had been used all the time, but the bursting occurred at night when there was no flow of water around the coil.

The problem was effectively solved by an architect who designed a tank along the lines of the accompanying sketch, which I consider an excellent solution, worthy of adoption by all refrigerating engineers for use where conditions are similar. An open box or tank was built tight enough to hold water. Two sets of coils were placed in this tank, with the ammonia coils above and the fresh-water coils below, as indicated. The tank was filled with fresh water and not with brine.

The ammonia coils, being placed at the top, are continually in the warmer portion of the water. If ice forms around the ammonia coils it makes no difference because there is plenty of space around them so that the walls of the tank are not touched by ice. At the bottom there is always a supply of cool water whose



Non-freezing water cooler

temperature is never any lower than 32 deg. F. This makes it impossible for the water in the fresh-water coils to freeze.

No trouble has been experienced since this change was made, and I can see no reason why there will ever be any trouble such as was had with the metal cooler that failed due to freezing. L. W. LOWERE.

Elizabeth, N. J.

Burning Anthracite on Stokers

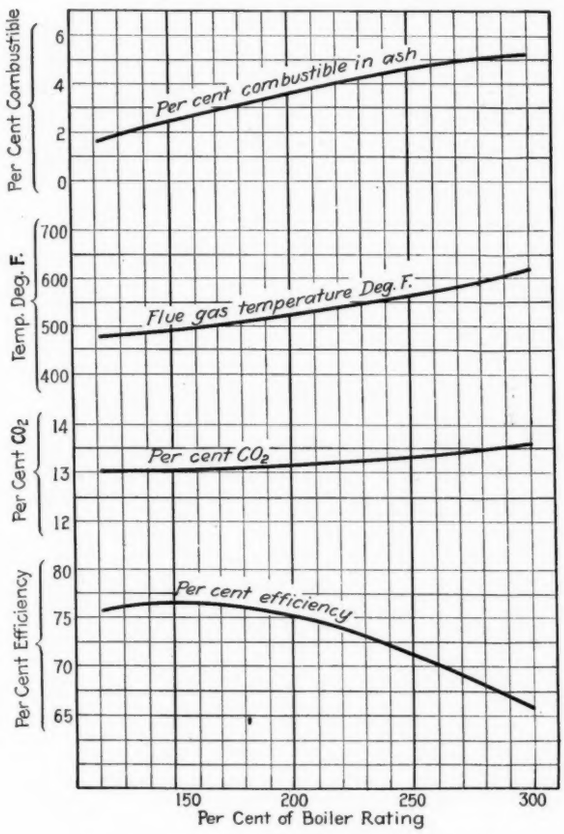
The article by Mr. Cary entitled "Burning Small Sizes of Anthracite," in the Feb. 26 issue, is rather interesting to one familiar with the operation of Coxe stokers. It is interesting because his reasoning is so contradictory to the facts derived from records of operation and numerous careful tests that have been made at our station, where efficiencies of over 75 per cent have been obtained with No. 3 buckwheat coal.

Mr. Cary is evidently arguing out a support for a sprinkler type of anthracite stoker. His paper has two parts. The first part reasons why a Coxe type is not good. The second part reasons why some sprinkler type is better. His conclusion is rather naïve—that he upon more than one occasion has given neighboring stokers, in competitive test, "some pretty close calls" in their endeavors to show better efficiency.

The strongest point that Mr. Cary brings up is the "ideal" method of burning this coal; that is, the adding

of fresh fuel (by sprinkling) on top of the whole surface and the removal of ash from the bottom. If this method is really ideal, it will give decidedly better efficiencies than Coxe stokers and not merely some pretty close calls. All stokers have two main losses, ashpit and flue. Any stoker or method of firing that materially reduces the usual sum of these losses with anthracite is unquestionably nearer an ideal. However, it is not evidence of an ideal machine to have made nearly as good efficiency as the neighboring stoker.

I desire to correct some rather serious errors in detailed statements made by Mr. Cary regarding the operating of Coxe stokers with anthracite coal. Before taking this up, there is a preliminary statement which runs counter to common understanding of chain-type stokers. This grate is decidedly not the type best adapted to coking bituminous coals. It is adapted to free-burning or non-coking bituminous coals. There is no action by the chain-type stoker corresponding to the fireman's action in breaking up the coke mass as described by Mr. Cary. This action is necessary with coking coals and is secured in the regular underfeed types of stokers. The conclusion that this points to refutes Mr. Cary's argument that the chain type is not suitable for anthracite because it is suitable for bituminous. The opposite is much nearer the fact.



Curves showing results obtained with small-sized anthracite coal

We know that anthracite contains much moisture and requires igniting. The moisture has to be driven off, and the ignition has to be secured, in any furnace that uses anthracite. So far as heat losses are concerned, there is and can be no choice. Whatever losses accrue from these causes will be identical for any firing method.

Mr. Cary's picture of an anthracite fire will not appear as a true picture to any operator of Coxe stokers. The idea that the first third of the grate is used to secure ignition will scarcely appeal as true to any of us who run white-hot fires out from the gate. The further statement that active burning is concentrated on the middle third or half of the stoker falls to pieces in the light of this same knowledge. Mr. Cary does, however, fairly well describe the rear third as a zone where the carbon is rather leisurely burned out of the ash, at least for medium loads, but does he realize that at times many of us burn active fires from the feed gates right to the rear end of the stoker?

There are some interesting points that Mr. Cary has not brought up. How many pounds of coal per square foot of grate can be burned by this ideal sprinkler method? Probably not over 25, possibly 30. What furnace temperature would this ideal furnace develop with anthracite coal? How little excess air can it use, without losing out in CO? It would require an almost ideal device to take ashes out from this ideal furnace; it is not so easy as it seems at first thought. And last, but not least, what ratings have been made, with what efficiencies, with anthracite coal?

When we can operate at over 75 per cent efficiency with anthracite buckwheat at loads up to 200 per cent rating; when we can jump our rating up to 300 and 350 per cent without effort; when we see our ash taken out with a nice gray color; when our flue temperatures are between 500 and 600 deg.; when two firemen make steam for 30,000 kw.; when we have all these things actually with us every day, in practical reality and not merely in an ephemeral ideal, we can hardly agree with Mr. Cary that Mr. Coxe was unfortunate in choosing the traveling grate as a commercial vehicle for burning buckwheat anthracite. The combined stoker and boiler efficiency curve in the accompanying set of curves illustrates what Mr. Cary's ideal stoker must do to compete with the Coxe stoker as we are operating it. These curves were made up from test data on our boiler No. 1, which is a B. & W., 13,450 sq.ft. of heating surface, fired by two Coxe stokers representing 346 sq.ft. of grate surface.

P. C. WIESNER, Engineer of Tests,
Adirondack Power & Light Corp.
Schenectady, N. Y.

Feed-Water Connection on Scotch Boilers

Replying to Mr. Summer's question in the March 25 issue as to why it is preferable to locate the feed-water entrance flange on that side of the Scotch boiler opposite which the water column is placed. The reasons for this are as follows:

Standard construction of Scotch boilers provides that the center of the lower water-column connection shall be about 8 in. longitudinally from the center of the inner row of forward ring-seam rivets. It also provides that the center of the feed-water flange shall be approximately 12 in. from the same rivet line. It follows that where both the water column and feed-pipe flanges enter on the same side of the boiler, great difficulty will be experienced in making repairs to either the feed-pipe flange or pipe and in making repairs to the water-column flange. In addition, with the smallest diameter Scotch boilers where both openings are on the same side they become too close together for good boiler-making practice.

WARREN HILLEARY,
Superintendent Royal Indemnity Co.
New York City.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Trouble from Babbitting of Main Bearing

We have been troubled with the babbitt breaking up in the main bearing of our engine. How can this be prevented? *W. L. D.*

Before babbitting, the recesses for the babbitt should be cleaned, scraped and tinned. Use a mixture composed of 3 parts copper, 89 parts tin and 8 parts antimony. Inferior grades of antifriction metal are principally composed of lead and wear rapidly. Before the metal is poured the boxes should be heated, and when cool the babbitt should be expanded by hammering.

Locating Oil Leak in Gas-Engine Crankcase

What is a practical method of locating a small leak in the bottom of the crankcase of a large gas engine without raising the engine off its foundation? We have examined the case from the inside and cannot locate the point where the oil is leaking. The entire crankcase drains out in about 24 hours of operation. *H. C. H.*

To locate the place of the leak, clean out the case and, after wiping the surface perfectly dry with a clean cloth, rub white lead over the interior where the leak might be located. Afterward rub off the white lead from the surface and turn the engine over a few times, taking care that no oil drops in the crankcase. The place of a leak will be revealed by the white lead being worked back to the surface by oil that was left in the crack. When found, the crack can be stopped with an iron cement.

Gathering Returns from Laundry Machinery

Where the condensation from calenders and other laundry machinery is to be returned to the boiler, cannot all returns be connected into one receiver with a single discharge trap, in place of using a separate trap on each machine? *L. H. E.*

Usually, there is considerable variation in the pressure of returns from laundry machinery, and dependence cannot be placed on discharging the returns from two or more machines into the same closed receiver unless the return pipes are independently dropped about 25 ft. before they are connected for drainage to the receiver. About 10 lb. per sq.in. lower return pressure from any machines will thus be increased by the head of water that may accumulate in the return pipe, permitting it to discharge to the receiver, where the pressure may be held up by a dry return from some other machine operating at higher pressure. When sufficient independent drop of the returns cannot be obtained to compensate differences of operating pressure, the machines will require separate traps for discharging their condensate.

Connection of Valve Stems in Duplex Pumps

Why are not the steam valves of a duplex pump firmly fixed to the valve stem as they are in a slide-valve engine? *D. N.*

In a duplex pump it is necessary to have lost motion, so there may be a pause in the flow of water at the end of the stroke to give the valves an opportunity to seat properly. The amount of lost motion becomes changed from wear, requiring adjustment. Therefore the steam valves cannot be firmly attached to the valve stems without providing clearance in a lost-motion link outside of the steam chest, which would be objectionable for small pumps or pumps that are not operated by a skilled attendant, since anyone could interfere with the adjustment.

Effect of Refitting Connecting-Rod Brasses

If the crosshead pin of an engine becomes reduced in size from wear, what effect would refitting and replacing the brasses without liners have on the piston clearance? *F. G. S.*

Reducing the length of the connecting rod between centers of crosshead and crankpin has the effect of reducing piston clearance in the crank end of the cylinder and increasing the clearance by the same amount in the head end of the cylinder; lengthening the rod has the opposite effect. Which would occur from tightening the crosshead brasses would depend on the style of connecting-rod end. Where the brasses are brought together by a movable strap, gib and key, driving up the key results in moving the strap and end brass nearer to the body of the connecting rod, with the effect of making the rod shorter, center to center of crosshead and crankpins, thus reducing piston clearance on the crank end and increasing clearance on the head end.

When the end of the rod is mortised or has a rigidly bolted strap for holding the brasses, tightening the wedge presses the brasses away from the wedge. When this type of connecting-rod end is used for the crosshead end of the rod, for better access the wedge is placed on the crankpin side of the crosshead pin. Then tightening the wedge has the effect of lengthening the rod with increase of piston clearance in the crank end and reduction of piston clearance in the head end of the cylinder. When wedges are used for adjustment of both crosshead and crankpin brasses, it is customary to have one of the wedges on the rod side of its pin and the other opposite to the rod; that is, both are toward the front or both are toward the rear. By this arrangement alteration in length of the rod from tightening the wedge of one end of the rod is counteracted by tightening the wedge in the other end.

Steam Discharged with Given Setting of Stop Valve

In one of our processes we throttle saturated steam at 120 lb. gage pressure through two ½-in. globe valves to about ¼ lb. gage pressure. The lift of the valves, as measured along the valve stems, is about 3/32 in. for each. From these data can an estimate be made of the amount of steam thus used? G. H. C.

The number of pounds of steam discharged through an aperture into a space where the pressure is less than 58 per cent of the initial absolute pressure is given by Napier's approximate formula,

$$W = \frac{P \times A}{70}$$

in which,

W = Pounds of steam discharged per second;

P = Absolute initial pressure, or gage pressure plus 14.7 lb. per sq.in., or 120 + 14.7 = 134.7 lb. absolute.

A = Area of aperture.

The area of the annular discharging aperture obtained with a flat disk valve having ½-in. diameter opening and actual lift of 3/32 in. would be 3.1416 × ½ × 3/32 = 0.0491 sq.in.; and for a valve with 45-deg. seat the discharge aperture would be 0.707 of 0.0491, or 0.0346 sq.in. Allowing the coefficient of discharge to be 0.96 in either case, the estimated discharge per the formula would be W = 134.7 × 0.0491 × 0.96 ÷ 70 = 0.0907 lb. per sec., or 326 lb. per hour, for a valve with flat disk, or W_1 = 134.7 × 0.0346 × 0.96 ÷ 70 = 0.0641 lb. per sec., or 231 lb. per hour, for a valve with seat beveled 45 deg.

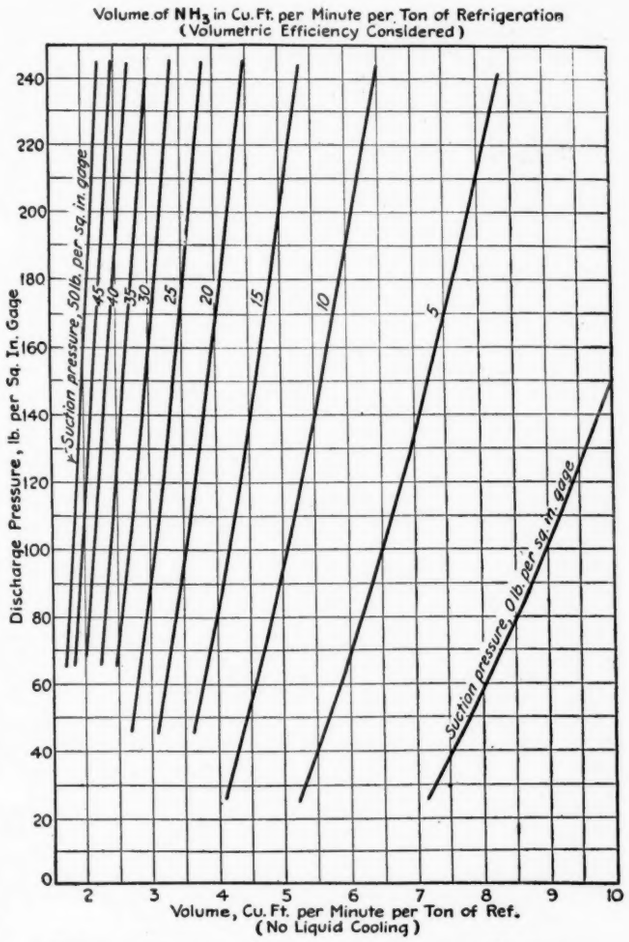
It is to be noted that in assuming only 3/32 in. lift of the valve, an error of 50 per cent would result from 1/64 in. lost motion between the valve and stem, wear of the valve disk or mismeasurement.

More reliable results would be obtained by setting the valve to the opening required by the process and, when steam is supplied at the regular pressure, catching the steam as it is discharged and condensed in about 50 lb. of water. Have the initial temperature of the condensing water not more than 60 deg. F., and note the increase of weight in a given time. The increase of weight in pounds divided by the number of minutes' duration of the flow of steam through the valve will be the weight discharged per minute. There should be no loss of steam to the atmosphere due to insufficient immersion of the discharge pipe or from continuing the experiment longer than necessary to raise the temperature of the water higher than about 100 deg. F., and the initial and final weighings of condensing water should be made with the discharge pipe detached so it may be completely drained of water.

Volume of Ammonia Vapor per Ton of Refrigeration

Is there any formula or chart whereby I can determine the speed an ammonia compressor must be run to perform a given refrigeration duty, with different suction and discharge pressures? R. L. D.

The first step is to find the volume of ammonia vapor which the compressor must handle. In the illustration are given a set of curves, each of which represents a certain suction or evaporating coil pressure. At the side of the chart is given a set of numbers representing discharge pressures. To use the chart, enter it at the point that shows the discharge pressure carried, say 180 lb. gage; move horizontally across the chart until the curve corresponding to the suction pressure is reached, say 20 lb. gage. Now move down and read the volume per minute per ton of refrigeration; in the case cited this is 4.2 cu.ft. This is the volume of gas, cubic



Volume of ammonia vapor for different discharge pressures

feet per minute, to be handled by the compressor per ton refrigeration.

The piston displacement in cubic feet of a single acting compressor is,

$$P.D. = \frac{3.1416\ D^2 \times S \times r.p.m.}{144 \times 4 \times 12}$$

where $P.D.$ = piston displacement in cubic feet per minute, D = cylinder diameter in inches; S = piston stroke in inches; the piston displacement = volume of gas handled per minute.

By transformation the formula becomes

$$r.p.m. = \frac{Vol.\ of\ gas \times 6912}{3.1416 \times D^2 \times S}$$

Substituting the proper values of the gas volume found from the chart, the cylinder diameter and piston stroke enables the r.p.m. to be found.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Per Cent of Rating

IN THE United States stationary boilers are generally rated on a purely arbitrary basis. They are said to be operating at "rating" when evaporating the equivalent of 3.45 lb. of water per hour "from and at 212" for each square foot of water-heating surface.

Water-heating surface is generally defined as metal surface in contact with hot gases where the other side of the same sheet or tube is in contact with water. Thus, in figuring the heating surface of boiler tubes, the inside surface is used for fire tubes and the outside for water tubes.

Why Heating Surface Is Measured on the Fire Side

This is a logical procedure because the metal temperature is always close to that of the water and the amount of heat transmitted (other things being equal) depends only on the difference of temperature between the gas and the metal. Thus, if the walls of water tubes should be made somewhat thicker by a slight reduction in the inside diameter, without any change in the outside diameter, the total weight of water evaporated per hour with a given rate of firing would remain practically unchanged. This would be the case because the amount and distribution of the metal surface exposed to the hot gases would be the same as before, while the thicker walls would not result in an appreciably higher temperature of the outer surface.

"From and At" Explained

The expression "from and at 212," often abbreviated to "f. & a. 212," refers to the evaporation of feed water at 212 deg. F. into dry saturated steam at the same temperature. This is a condition under which few boilers operate, but it is necessary to take some definite set of conditions as a standard. Evaporation at 212 deg. implies that the pressure carried is atmospheric, 14.7 lb. per square inch.

Almost invariably the actual pressure carried is greater than this. It is also generally true that the feed temperature is lower than 212 deg. Both these conditions increase the heat required to turn a pound of feed water into a pound of steam. Credit is always given to the boiler for these more difficult conditions when figuring the percentage of rating actually developed.

This is taken care of by the "factor of evaporation," a number (generally slightly greater than unity) by which the actual amount of water evaporated under the given conditions must be multiplied to get the equivalent evaporation from and at 212. By the "equivalent evaporation" is meant the amount that would be evaporated from and at 212 if the same total quantity of heat was utilized for steam generation as was utilized under the actual conditions. The factor of evaporation is then a figure showing the relative difficulty of generating a pound of steam under the actual conditions as compared with the standard conditions.

Figuring Factor of Evaporation

While tables of factors of evaporation are commonly available, the engineer should understand how such a factor is figured. The data needed may be found in the steam tables, which give the total heat of dry and saturated steam. The method of computation is best explained by an example. Suppose that steam is generated at 200 lb. gage pressure and 150 deg. superheat and that the feed temperature is 195 deg. The amount of heat required to transform one pound of the feed water into the superheated steam can most easily be figured by subtracting the heat content of the water from that of the steam. Adding 15 lb.[1] to 200 gives an absolute steam pressure of 215 lb. The steam tables give the "total heat" of steam at 215 lb. absolute and 150 deg. superheat as 1,284.6 B.t.u. All heats given in the steam table are "above 32 deg." so this figure means that it would take 1,284.6 Btu. to heat a pound of water from 32 deg. up to the boiling point at this pressure, evaporate it and superheat it the indicated amount.

The heat in the feed water may likewise be obtained from the steam tables, but it is generally figured directly by subtracting 32 from the feed temperature. In this case it is 195 — 32 = 163 B.t.u. This follows from the fact that water, in being heated from 32 to any desired temperature, takes (for one pound) almost exactly one B.t.u. for each degree rise.

Figuring Heat Required to Make Pound of Steam

The heat required to make a pound of the superheated steam from the given feed water is then 1,284.6 — 163 = 1,121.6 B.t.u. To generate a pound of steam from and at 212 requires only 970.4 Btu., which is the latent heat of evaporation at atmospheric pressure. It is evidently harder to generate a pound of steam under the given conditions than from and at 212. The relative degree of difficulty can be exactly represented by the ratio 1,121.6: 970.4 or 1,121.6 ÷ 970.4 = 1.1558. It is not generally worth while to carry the factor of evaporation more than three decimal places, so this may be written 1.156.

If the size of the boiler and the total amount of water evaporated per hour are known, the per cent of rating can be figured without difficulty. Suppose the boiler has 3,200 sq.ft. of water-heating surface and is producing steam at the rate of 14,320 lb. per hour. The rate per square foot is then 14,320 ÷ 3,200 = 4.475 lb. per square foot per hour. The factor of evaporation has already been figured as 1.156. Multiplying this by 4.475 gives an equivalent evaporation, from and at 212, of 5.173 lb. per square foot per hour. Since the arbitary rating of boilers is the evaporation of 3.45 lb. per square foot per hour from and at 212, the fraction of rating actually developed in this case is 5.173 ÷ 3.45 =1.50, or 150 per cent.

Convenient Short Cuts

It has already been mentioned that tables of factors of evaporation are commonly available. A still more convenient table is one that gives directly the amount of water that must be evaporated per hour per square foot to give rated capacity for any feed temperature steam pressure and amount of superheat.

Such a table is not difficult to make. The first step is to reduce the rated boiler output per square foot per hour to B.t.u. This is evidently 3.45 × 970.4 = 3,348 B.t.u. If this is divided by the amount of heat required to make one pound of steam under the given conditions, it will give the desired result.

In the case just discussed it took 1,121.6 B.t.u. to make one pound of steam, which gives 3,348 ÷ 1,121.6 = 2.985 lb. per square foot per hour. If the actual evaporation per square foot per hour is divided by this figure and multiplied by 100, it will give directly the percentage of rating.

Making a Per Cent Rating Table for Special Conditions

Still further simplification is possible in certain cases. If the computations are always to be made for a certain boiler, a table may be prepared giving the rated evaporation for the entire boiler rather than for one square foot. This saves dividing by the square feet each time the percentage of rating is figured. Moreover, if a table is to be made for use with a given boiler in a given plant, the range of pressures and temperatures likly to be met is small, so that the table need not be very extensive.

[1] While 14.7 lb., rather than 15 lb., is the correct standard for atmospheric pressure, the latter is quite close enough for figuring the absolute pressure except where the gage pressure is very low (close to atmospheric).

Water Power Discussed at A. I. E. E. Spring Convention

AMONG the subjects discussed at the third spring convention of the American Institute of Electrical Engineers, held in Birmingham, Ala., April 7 to 11, were hydro-electric developments, relay and lightning-arrester protection and experiences with circuit breakers of large rupturing capacity. More than three hundred and fifty registered at the convention. Seven technical sessions were held on various subjects, with one general session on water-power developments.

The subject of the first session of the convention, Monday afternoon, was the engineering features of hydro-electric developments. A résumé of hydro-electric practices and equipment in the South was given in a paper by O. G. Thurlow and S. A. Sirnit, both of the Alabama Power Co. The paper pointed out that the absence of snow and the general topography of this part of the country produce water conditions such that wide variations in flow occur. The annual precipitation in the South is 40 in. to 80 in., with a ratio of rainfall to run-off varying from three to two in the headwaters to four to one or two to one in the foothills, depending upon dry or wet seasonal conditions respectively.

Most of the rivers yield only run-of-river power, with very little primary and a large amount of secondary power, and require supplementary steam plants or storage basins for the full utilization of their possibilties. Most of the developments are low-head, and the use of heavy-gravity dams is essential because of floodwater demands. An abstract of this paper will appear in an early issue.

Practice on Pacific Coast

A paper, "Hydro-Electric Practices and Equipment on the Pacific Coast" was presented by Svend Barfoed, consulting engineer. Topographical features on the Pacific Coast were described and data given on precipitations and run-off in the several sections. In general, storage is used, and it has proved economical to use steam plants to carry peak loads to supplement the water power and to give service insurance. The author stated that long pipe lines contain moving water columns of thousands of tons weight which must never get out of control. If control is lost, disaster is swift and certain. Aside from the control obtained through the governor, stop gates or valves are placed in long lines at both top and bottom. For short lines and single-unit plants the valve at the bottom is sometimes omitted. In the older plants the gates at the top were simple devices often made of wood; in later plants valves have been introduced directly in the pipe line, just after leaving the forebay or surge tank. Both slide valves and butterfly valves are used, and the latter seem to be gaining in favor and so far have given good results. The butterfly valve is sufficiently tight when carefully made, and the body of its closing disk can be made of efficient form with respect to the flowing water. At the power-house end slide valves butterfly valves and plunger valves have been used with uniformly good results, with the exception of the control for the plunger valve, which has not been positive and powerful to the degree required by the high pressures and long lines used on the Western Coast.

W. M. White, of the Allis-Chalmers Manufacturing Co., presented a paper on "Recent Developments in Hydro-Electric Equipment," an abstract of which will appear in an early issue.

Tests on Waterwheels

"Acceptance Tests for Hydro-Electric Plants," was the subject of a paper presented by Frank H. Rogers, chief engineer, I. P. Morris Dept., Wm. Cramp & Sons. In this paper the author deals with the methods of making tests as outlined in the test codes of the Machinery Builders Society and the American Society of Mechanical Engineers. The effective head on the turbine is defined as, "the difference between the total energy contained in the water immediately before its entrance to the turbine and the total energy in the water immediately after its discharge from the draft tube." It is shown how this head is determined and how corrections are made when the speed of the turbine under test cannot be adjusted to the proper value for the head under which the test is made. Methods of measuring the flow of water are gone into, such as Pitot tubes, current meters, Allen salt-velocity and Gibson methods. A series of tests made on Pitot tubes with the axes of the nozzles parallel to the line of flow and then with the nozzles at various angles to the line of flow, showed that all types of tubes gave correct velocity when the axis of the tubes was parallel with the line of flow and gave a higher velocity than the resolved velocity when the axis of the nozzles was inclined at an angle to the direction of flow.

The author states, "Absolute straight-line stream flow is very difficult to produce in laboratory work and is never obtained in practice when water is flowing in pipes or open channels at ordinary velocities. The flowing mass of water is full of local whirls, so that at any given point the velocity varies both in direction and magnitude. Therefore under the usual conditions met with in engineering, a coefficient less than unity must be used to correct the quantity obtained by Pitot tube measurements. This coefficient, however, has a small range in actual value, its limits for ordinary conditions being unity and 0.96. The Machinery Builders' Code fixes the value at 0.976 as the average obtained from a large number of comparative tests, and the A.S.M.E. Code gives the coefficient as 0.98."

"Current meters," says Mr. Rogers, "have been used very widely for gaging the flow of streams and rivers and also in determining the flow in tests of hydraulic turbines where a canal or flume is available. They should be used only where reasonably straight and smooth flow may be expected to occur, and therefore a long straight run of flume of rectangular cross-section should be available. It is always preferable to locate the current meters on the intake side of the plant rather than in the tailrace, as the flow conditions in the tailrace are usually much more disturbed.

"A great many experiments have been made to determine the accuracy of quantity measurements by current meters, using the still-water ratings of the meters and comparing the readings with the flow determined by some other method of measurement, and it has been found that the still-water ratings are not reliable as oblique or disturbed flow affects the readings of the meters in a somewhat similar manner to the effect of such flow on Pitot tubes. Unlike Pitot tubes, however, it is found that some types of flow meters read too high and other types too low. Thus the cup-type meters invariably read high and the screw-type usually read low."

In speaking of the Allen salt-velocity and the Gibson methods, the author states that "while these are of very recent origin, they have been thoroughly tried out and found to give a high degree of accuracy and reliability."

Discussion of Papers

In the discussion of the papers W. S. Lee, Southern Power Co., stated that distances from manufacturers or materials influenced the choice of dams, but that for the South it was best to use heavy-gravity dams. He said the multiple-arch dam was utterly unsuitable and that, in his opinion, the concrete-core-wall earth dam was a mistake and it would be better to use a solid earth dam where such dams are built at all. P. M. Downing, Pacific Gas & Electric Co., said that multiple-arch dams are used on the Pacific Coast only where water conditions and construction conditions are favorable. He added that steam plants are most economical for handling peak loads even where the daily load factor is 80 per cent and the yearly load factor 65 per cent, if the distances are great and the investment in hydro-electric developments is high.

George A. Orrok, consulting engineer, New York, said that cavitation occurred in waterwheels both in Europe and America and the art must be developed before this action could be eliminated. W. M. White said that cavitation resulted because high specific speeds were used to accommodate the generator speed conditions and that a total economic minimum cost of a unit dictated such speeds that cavitation might occur. He stated that cavi-

tation was not a serious matter and that if a hole pierced the runner further action ceased and little leakage occurred. W. S. Lee corroborated Mr. White in the last statement and added that cavitation always occurred on the discharge side. P. M. Downing asserted that he had noticed a pitting on the face of the impulse-wheel buckets which was similar to the cavitation effect on wheels. W. E. Mitchell, Alabama Power Co., said it was impossible to prevent cavitation if the load and speed of units were variable for a given installation. F. H. Rogers, at the request of Mr. Mitchell and others, elaborated the method proposed for securing maximum efficiency in hydro-electric operation.

Southern Power Developments

An address by Thomas W. Martin, president Alabama Power Co., on Southern power developments was a feature of the Tuesday afternoon session. In this address Mr. Martin showed how electrical power had made possible the great industrial progress of the past few years. He also presented an analysis of the Muscle Shoals situation and discussed the various offers now before Congress. In discussing power conditions in the South, Mr. Martin stated that in 1923 the output of the power companies in the interconnected group was more than three billion kilowatt-hours, an increase of 20 per cent over 1922. The maximum demand on the systems is 750,000 kw. and the connected load more than 2,000,000 hp. By 1924 there will be an installed capacity on the systems of 1,781,155 kva. with an estimated output of more than five billion kilowatt-hours. The value of interconnection was indicated by the fact that 87,000,000 kw.-hr. was interchanged in 1921 and 236,000,000 kw.-hr. in 1923. Mr. Martin said that interconnection was the logical working out of economic laws and that the utilities concerned had vision sufficient to grasp the possibilities of interconnection.

National Aspects

On Tuesday night O. C. Merrill, executive secretary of the Federal Power Commission, gave an address on national water-power development. After pointing to the great hydro-electric development of the Western coast, Mr. Merrill discussed the superpower systems which the government hopes to see interconnected in a nation-wide web of transmission lines. This development is economic and expedient, he said, for the reason that electric power cannot be stored, and interconnection with other lines transmitting power to a distance will make it possible for each system in the general plan to dispose of energy not needed locally except at the "peak" hours. Superpower distribution, he said, will provide improved electrical service, will make practicable a much greater use of the nation's water powers, with a consequent saving of fuel and reduction of rates and, finally, will bring about the decentralization of industry.

The federal government today is exercising control over about 85 per cent of all the water-power resources of the country, he said—a step in conservation that was taken in time, unlike the history of the exploitation of other public resources. "This control is being exercised for two primary purposes," Mr. Merrill declared, "to guard against improvident use of a public resource and to retain these resources in public ownership that they may not be capitalized for purposes of rate making or of sale."

Another paper of interest to *Power* readers was that by W. J. Foster and A. E. Glass, both of the General Electric Co. An abstract of this paper appeared on page 622 of the April 15 issue, and describes the 65,000-kva. generators being installed by the Niagara Falls Power Company. One of these generators went into service Dec. 18 of last year, and a second unit is about ready to go into operation.

Boiler Safety Devices

By A. L. H. Street

That an employer may subject himself to liability for injuries sustained through explosion of a boiler, resulting from failure to equip it with a safety device, although there may be some difference in expert opinion as to the advisability of using it, is shown by the decision of the United States Circuit Court of Appeals, Sixth Circuit, in the case of Groeger vs. Baltimore & Ohio Railroad Co. (288 Federal Reporter, 321). In that case judgment against defendant railway company, on account of death of a locomotive engineer, in an explosion of the boiler of his engine, was affirmed on the theory that the jury were warranted in finding that there was negligence in failing to equip the locomotive with a fusible plug. In the course of its opinion, the Court said:

"It is claimed on behalf of plaintiff in error that the weight of the evidence directed to that issue, establishes the fact that fusible plugs are not in general use by railroad systems; that they have never been accepted and used by master mechanics and locomotive engineers as standard equipment in locomotive service; that while fusible plugs present an element of safety, and would probably have prevented the explosion in this case, nevertheless they accumulate scale on the top of the plug, and this permits the plug to heat, so that the soft metal will melt and run out, causing the engine to fail in service on the line, and that sometimes this results in injury to the fireman, if he should be firing just at the time the soft metal runs out of the plug, permitting the steam to blow the fire and hot cinders out of the door of the firebox; and that the presence of a fusible plug tends to negligence on the part of the engineer in failing to keep sufficient water in the engine.

"There is, however, substantial evidence in this regard tending to prove that fusible plugs are extensively used; that they may be rounded at the top, so that the scale will not accumulate thereon; that they are generally recognized as effective and reliable means for preventing boiler explosions from low water; and that if this engine had been equipped with a fusible plug this explosion would not have occurred, regardless of the other claimed defects."

Explosion of 20,000-Kw. Turbine at Shanghai

The Dec. 25, 1923, issue contained an account of the failure of the rotor in a 20,000-kw. turbine at Shanghai, China, which occurred on Nov. 15, 1923. This account was taken from the *North China Daily News* of Nov. 16. It appeared, from the evidence presented at that time, that failure was due to a breakage of the rotor rather than from overspeed.

A report sent out by Messrs. C. A. Parsons & Co., Ltd., for general information, published in *The Municipal Gazette* of Shanghai, March 13, 1924, gives several reasons why overspeed should not be construed as the cause of this wreck. The report further states that examination of the rotor, which is a large forged, rigid piece, discloses that the accident was evidently due to a fracture.

This fracture appears to have been the result of a concealed defect in the interior of the steel forging. The shaft was made from a cold ingot, in 1921, when manufacturing precautions which are now in force were not then practiced.

All medium-carbon steel forgings of large or varying sections are now treated in a manner similar to the highest class of alloy steel for ordnance. This comes under the direct supervision of the steelmakers' metallurgical experts. From the casting of the ingot to the final operation of heat treatment the material is not now allowed to become cold.

The fact that the rotor in question had been allowed to cool and was again heated during the process of manufacture, is the probable cause of the trouble.

At the present time it appears to be the universal practice to bore holes through the centers of shafts for the purpose of internal examination. This reduces the possibility of a repetition of such an accident to the minimum.

Power Test Codes Show Progress

The Power Test Codes Committee has arranged for the printing of a limited number of galley proofs which will be available to every member of the A.S.M.E. who requests them and is willing to contribute to the success of the work by sending in his criticisms and comments, of the following codes: Steam turbines; reciprocating displacement pumps; centrifugal and rotary pumps; evaporating apparatus; instruments and apparatus (5 sections) tests for condenser leakage, glass thermometers, pressure gage thermometers, differential-expansion thermometers, optical thermometers. Three codes are now available in pamphlet form: "General Instructions"; "Reciprocating Steam Engines"; "Hydraulic Power Plants."

The Test Codes for "Stationary Steam Boilers," "Feed-Water Heaters," "Locomotives," and "Internal-Combustion Engines," will be presented to the Council for approval, after which they will be printed in pamphlet form.

Muscle Shoals Committee Appointed by A.E.C.

In compliance with a request from Senator Norris, chairman of the Senate Agricultural Committee, the Administrative Committee of the American Engineering Council has chosen a committee to make a report on the disposition of the government's Muscle Shoals properties. The committee is composed as follows: Fred R. Low, New York, editor of *Power* and president of the American Society of Mechanical Engineers, chairman; Dr. H. E. Howe, Washington, editor of *Industrial and Engineering Chemistry* and member of the American Institute of Chemical Engineers; H. W. Buck, consulting engineer, of New York, and past president of the American Institute of Electrical Engineers; Prof. H. B. Walker, Kansas State Agricultural College, member of American Agricultural Engineers and Kansas Engineering Society; Prof. B. Davidson, Iowa State College, member of the American Society of Agricultural Engineers; Ezra B. Whitman, Baltimore, chairman of Public Utilities Commission of Maryland, member of board of directors of the American Society of Civil Engineers and recommended by President Grunsky; Dr. Leonard Waldo, consulting engineer, of New York City; Philip N. Moore, member of the Associated Engineers, St. Louis, Mo.

The committee held its first meeting in Washington April 15, at the Cosmos Club. Senator Norris in his letter to the council said:

"After this committee has reported, I would like to have some of its members appear before the Senate Committee so that they may be questioned in regard to their report and the general problem involved." This committee is scheduled to appear on April 24.

Why Congress Gave Dixie Power Co. Extension

Consideration for the small investors who own most of the stock of the Dixie Power Co. was the influence behind the passage by the Senate and the House of a bill extending for eighteen months beyond the three-year limit the preliminary permit of the company covering a site on White River in Arkansas. In recommending the passage of the bill, the Committee on Interstate and Foreign Commerce made these statements in its report:

"Stock of the par value of $220,000 was sold to many subscribers, principally local residents. The company procured a preliminary permit, which was extended for the limit of three years allowed under the water power act. The permit expired March 1. The company performed part but not all of the engineering and other work necessary to qualify for a license under the Federal Water Power Act.

"On April 3, 1923, the Dixie Power Co. entered into a contract with Hugh L. Cooper and Co., by the terms of which the latter company agreed to perform the necessary work and protect the permit under the Water Power Act. For reasons constituting controversies between these companies, the merits of which this committee does not undertake to determine, the permit of the Dixie Power Co. expired without a license having been procured. On Jan. 23, 1924, Hugh L. Cooper & Co. applied to the Federal Power Commission for a permit in its own name, and now claims it was justified in so doing. The controversies of the two companies safely may be left to mutual adjustment or to the courts."

State Engineers Interested in Interconnections

State engineers from a number of the commonwealths interested in superpower conferred with Commerce Secretary Hoover on April 14, when it was agreed that they will lay the facts which have been developed before the Public Service Commissions of their respective states.

On the basis of these facts it is hoped that the Public Service Commissions may be induced to suggest legislation which would facilitate and encourage the interstate flow of power.

Another Steam-Electric Plant for Philadelphia

A new steam-electric power plant is to be built by the Philadelphia Electric Co. at Wheat Sheaf Lane on the Delaware River. The electric engineers are designing it for an ultimate capacity of 600,000 kw., the first third of which is to be built at once.

The demand for electric power in Philadelphia has grown so rapidly that before the completion of the Delaware station of the Philadelphia Electric Co. was finished, this new plant was planned. J. S. Adey, of Stone & Webster, will be superintendent of construction.

Grand Rapids Committee of N.A.S.E. Announced

The Grand Rapids National Convention Committee, N.A.S.E. for the convention to be held in Grand Rapids, Mich., Sept. 8-13 has been chosen as follows:

George J. Bulliss, general chairman of the local committee; State President Burgess, of Detroit, honorary chairman of the auxilliary committee on exhibits; Jack Chalmers, treasurer of the general committee; Williams Yeomans, secretary of publicity; Harry Johnson, Vern Pope, Jack Chalmers, James Boetsma and Harry Idsenga, the entertainment committee; Frank Gleason, chairman of the exhibit committee; William Gormley, William Lawton, William Ten Hopen, Martin De Yonge, reception committee; O. J. Dykman, Howard Nickelson and Ray Johnson, the hotel committee.

Large Generators Ordered for Wilson Dam

The War Department has just placed an order for four 32,500-kva. vertical waterwheel G.E. generators, each with direct-connected exciter for the Wilson dam hydro-electric project at Muscle Shoals. The four generators are each rated 32,500 kva., 26,000 kw., 0.8 p.f., 100 r.p.m., 12,000 volts, three-phase, 60 cycle.

These 26,000-kw. units will comprise a part of the proposed installation of eighteen units, which will have a total ultimate generating capacity of approximately 450,000 kw. Delivery on the order will be made during 1925.

Boulder Canyon Project Still Under Discussion

Hearings on the Swing-Johnson bill nearing a close in Washington, have brought out two dominant considerations in the issue. First, Can the rights of the upper stream states be protected by inserting specific provisions in the bill that will insure them against loss of their water rights through a prior appropriation at Boulder Canyon reservoir? Second, Will there be a market for the sale of 600,000 hp. to be generated at the site, and which is depended upon to amortize the cost of the dam?

Los Angeles, according to the testimony of T. A. Panter, electrical engineer of the Bureau of Power and Light of the City of Los Angeles, who would have charge of the distribution of the power which would be taken by the city from the project, told the committee that "Los Angeles would guarantee to take whatever power is left after other communities are served," and said that the rate at which the city is growing makes it evident that the consumption of hydro-electric energy will increase from the present 100,000 hp. to 600,000 hp. by 1930. He explained that the first generating plant can be built as soon as the dam reaches half the contemplated height of 605 feet.

O. C. Merrill, recalled to the stand to explain certain phases of the recent Federal Power Commission report opposing development of the Colorado River as provided in the Swing-Johnson bill, was forced to admit that he had gone outside the specific provisions of

the measure in the recommendation submitted. Mr. Merrill insisted that he had merely intended to "point out in round figures what the project was likely to cost before it was through, and that this money would be a charge against the United States whether it was paid out of the authorization or elsewhere," when it was charged by Mr. Little that the Federal Power Commission attempted to create an unfavorable sentiment against the project by "scare head estimates," which are not contemplated in the actual terms of the bill.

Conversion to Oil Burners May be Opposed

It is understood in Washington, that if the conversion of coal-burning battleships of the Atlantic scouting fleet into oil burners would lead other nations who are parties to the naval limitations treaty to make similar outlays, the conversions would be opposed by President Coolidge.

Electric Steam Boiler Explodes

Recently, an electric steam boiler exploded in the City of Winnepeg, Canada, and caused considerable property damage. There seems to be some doubt as to whether the accident was due to causes that might produce an explosion in a fuel-fired boiler or whether, as suggested, it was due to ignition of hydrogen gas in combination with oxygen. It is expected that in the near future more detailed information on the accident will be available.

Mexican Oil Production Decreases

Production of crude petroleum in Mexico in the year 1923 decreased to 149,529,088 bbl. from 182,278,457 bbl. in 1922, according to a report recently issued by the Mexican Department of Petroleum. The commercial value of the 1923 production was 285,833,771 pesos, in comparison with 334,795,744 pesos for the 1922 production.

The production of heavy oil in the Mexican fields is now greater than that of light oil, which was in the lead until a few years ago. This increase in the production of heavy crude is principally due to the development work along the banks of the Panuco River, and particularly in the Hacienda of Cacalilao.

Muscle Shoals Hearings Schedule

At the opening session of Senator Norris' committee, April 16, Elon H. Hooker appeared to discuss his proposal for the Muscle Shoals properties as incorporated in S. 2747. Senator Norris gave the press the schedule of further hearings. It may be inferred from the way in which Senator Norris referred to further plans that only those who request an opportunity to be heard will be scheduled. The schedule is as follows:

April 22—Tennessee Manufacturers Association; Dr. Jos. H. Pratt, Western North Carolina Development Association, Ashville, N. C.

April 23—Chamber of Commerce, Charlotte, N. C.; John A. McSparren, Master, Penna. Grange, Furnis Farm, Lancaster, Pa.; Engineers Association, Nashville, Tenn.

April 24—Mississippi Development Board, Hattiesburg, Miss.; American Society of Civil Engineers; American Engineering Council.

April 25—Newton D. Baker.

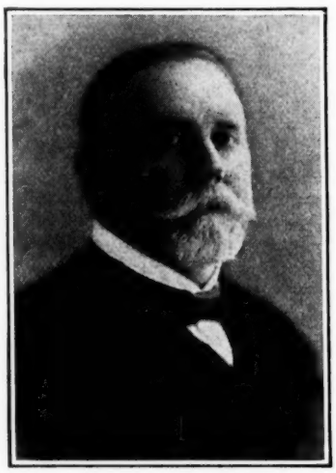
April 26—W. T. Drummond, Director, International Farm Congress, Kansas City, Mo.; Morris L. Cooke, Philadelphia.

April 28—Henry S. Graves, Yale University; Harry A. Garfield.

April 29—Gifford Pinchot, Harrisburgh, Pa.

Wilhelm Schmidt Dies at Sixty-four

A pioneer in work relating to the art of steam superheating, Wilhelm Schmidt, died Feb. 16, at Bether near Bielefeldt, Germany, at the age of sixty-four.



Wilhelm Schmidt

Dr. Schmidt's life is remarkable when viewed with an appreciation of the limitations which are in the European countries placed upon the individual by tradition of class and education. Son of a villager, he started his career as a locksmith, and it was through various happy coincidences that his natural ability to speculate correctly on matters of physics and engineering came to the attention of prominent men who made it possible for him to educate himself.

In his early years he recognized the importance of superheating steam for the economy of steam engines and spent the greater part of his life in fighting prejudices that made engineers opposed to this practice, and to build up an organization which was finally able to overcome these difficulties and carry his ideas to commercial success.

Within the last ten years of his life he spent much effort and vast sums of money on the demonstration of practical ways and means to combine the thermal pressures, which he termed "superpressure." While he did not live to see his inventions widely exploited, he had the satisfaction of having the engineering fraternity of his own country acknowledge the genius of his conceptions. He received many honors, one being the degree of Doctor of Engineering conferred upon him by a university of his own country.

Great Falls Plans Passed by Senate

Without a single voice raised in objection, the Senate on April 10, without a roll call, passed the Norris bill providing for the development of Great Falls on the Potomac near Washington. This is the third time the Senate has passed this bill. One of the previous bills died in the House with the end of the session of Congress. The other reached the conference stage, but resulted in a compromise whereby a further report was to be made. This was the report made by Major Max Tyler.

There will be objection to this bill in the House on the ground that an expenditure of $45,000,000 is not justified at this time. Passage of the bill by the Senate during the first session of Congress increases the chances of its ultimate success.

The bill as passed by the Senate authorizes the Secretary of War to undertake the development along the lines indicated in the Tyler report, but the Federal Power Commission is authorized to make any modifications or changes in the Tyler plans so as to increase the maximum amount of power that can be developed.

Scale-Removing Compounds Get New Freight Rate

Boiler preservative and scale-removing compounds in liquid form in the future are to take a fifth-class instead of a fourth-class freight rating and will be given the advantage of a minimum carload loading of 36,000 lb. This action has been taken in a decision handed down by the Interstate Commerce Commission on a complaint brought by the Garratt-Callahan Co., of Chicago, manufacturers and dealers in such compounds. The commission in its decision, among other things, indulges in the following comment:

"The basic ingredient in these compounds is sodium silicate. The lesser ingredients are not stated, being trade secrets, but were selected for specific purposes. Shipments are made in bulk in barrels, half barrels, kegs and drums. The compounds are harmless to metals, fabrics or the person, are not inflammable and will not freeze. They are soluble in water and can be washed readily from car floors or platforms. Claims against the carriers for damage in transit are negligible. The sale prices range from 60c. to $1 per gallon.

"In use they are mixed with the feed water as it enters the boiler. On reaching the hot water, they enter the crevices or other voids, expand and force from the boiler shell the scale deposited by impurities in the water. The action is thus mechanical and not chemical, differing from ordinary water softeners or boiler compounds which chemically

purify the water to prevent scale or cause precipitation of impurities. They differ from boiler cleaners that dissolve the scale and bring it down in the form of mud for ready removal.

"The complainants name other liquid compounds which move at or near the ratings sought, such as sodium silicate, various acids in carboys, buffing and polishing, anti-freezing, bleaching, fertilizing, food-preserving, straw-softening, rust-preventing, paint- and varnish-removing and wood-preservative compounds, with 30,000 or 36,000 lb. minimum. Comparable with boiler-preserving compounds and boiler-metal treatments in unit, weight and price, are some liquid paints rated fifth class, minimum 36,000 lb. Harness, shoe or leather dressing, stove polish and automobile top dressing, comparable in weight and value of boiler-preservative compounds, recently have been reduced to fifth class in official classification, minimum 30,000 to 40,000 lb. Most sodium chemicals are rated fifth class in official classification."

California Hydro Plants Lack Water

According to press reports the lack of snow and rain in the Sierra Nevada Mountains threatens to reduce substantially the hydro-electric output of California, with consequent effect on economic conditions. Steam plants which are being rushed into service are said to be unable to meet the demand.

Welding Society Program of Papers

The American Welding Society will have on its technical program at its annual meeting, April 23-26 papers as follows: "Flexibility Versus Rigidity in the Design of Welds"—a. "Carbon Arc Welding," by J. C. Lincoln; b. "Gas Welding," S. W. Miller; c. "Metal Arc Welding," by C. J. Holslag; d. "Resistance Welding," by H. A. Woofter; e. "Thermit Welding," by J. H. Deppeler; "Welding in Railroad Shops," by A. G. Pack.

American Engineering Council Announces Committees

The American Engineering Council has announced the personnel of some of its committees and appointments of representatives to act with other national bodies here and abroad. They are:

Reforestation and Timber Supply—J. C. Ralston, of Spokane, chairman; Samuel M. Kennedy and C. C. Thomas, of Los Angeles; G. H. Wilsey, of St. Paul; A. F. Ganier, of Nashville; John S. Barelli, of New Orleans; Dean M. E. Cooley, University of Michigan; C. E. Paul of Chicago, and Dr. Raphael Zon.

Government Reorganization as Related to Engineering Matters—Gardner S. Williams, of Ann Arbor, chairman; Francis Blossom, L. B. Stillwell and J. Parke Channing, of New York; J. H. Finney, of Washington; John Lyle Harrington, of Kansas City, Mo.; P. N. Moore, of St. Louis; Max Toltz, of St. Paul, and Hunter McDonald, of Nashville.

Public Affairs—Calvert Townley, of New York, chairman; L. P. Alford and F. B. Jewett, of New York; Prof. D. C. Jackson, of M. I. T., Boston; Fred J. Miller, Pennsylvania Public Service Commission.

War Department Personnel—Dean Arthur M. Greene, Jr., Princeton, chairman; President S. W. Stratton, of M.I.T., Boston; Prof. C. F. Scott, of Yale; Dean Dexter S. Kimbell, of Cornell; F. L. Hutchinson, of New York; H. W. Eales, of St. Louis; W. G. Sheehan, of Detroit.

Elimination of Waste in Industry—F. K. Copeland, of Chicago, chairman; Dean Perley F. Walker, University of Kansas; B. A. Parks, of Grand Rapids.

Federal Power—William McClellan, chairman; E. B. Katte, of New York; C. G. Adsit, of Atlanta; F. G. Baum, of San Francisco; Erskine Ramsey, of Birmingham; C. C. Thomas, of Los Angeles; J. H. Finney, of Washington.

Patents—E. J. Prindle, of New York, chairman; F. P. Fish, of St. Louis; A. E. Lindau, of Buffalo; F. E. Flanders, of Springfield, Vt.; E. W. Rice, Jr., of Schenectady; Charles A. Terry, of San Francisco; William Schwanhausser, of New York.

Contracts and Adjustments—Max Toltz, of St. Paul, chairman; Prof. Comfort A. Adams, of Harvard; W. A. Darling; David R. Lyman; George R. Putnam; H. M. Southgate.

World Power Conference Delegates—Calvert Townley and Fred R. Low, of New York; John M. Finney, of Washington.

National Bureau of Economic Research—W. R. Ingalls, of New York.

Board for Jurisdictional Awards—Rudolph P. Miller, of New York.

New Fishway System to Solve Dam Problems

Apparently, means have been found whereby one of the serious problems facing the construction of a dam on the Columbia River at Priest Rapids can be overcome. The proposed dam would cut off salmon from extensive spawning ground. The license for the project will require the construction of a fishway. The Bureau of Fisheries heretofore has taken the position that fish will not cross a dam over thirty feet in height. That Bureau, however, is about to revise its opinion, it is understood, as a result of experiments in California where large numbers of fish have crossed dams of greater height. This has been made possible by providing a series of resting pools.

It is believed that this improved method of constructing fishways is of great significance to the power industry on the west coast and in Alaska. There are many important rivers on which power dams are being strenuously opposed by those interested in the fish industry.

Fourth International Congress of Refrigeration

Program of Papers and Discussion to Be Held Under the Auspices of the International Institute of Refrigeration, at the Ministry of Labor, Whitehall, London, June 16-21

Commission 1: *Physics, chemistry and thermometry*

Professor Kamerlingh Onnes' experiments at Leyden University in low temperatures in connection with gas, paramagnetism, the Thomson effect, helium vaporization, properties of alloys, etc.

Commission 2: *Study of units*

Wishes of the Paris and Chicago Congresses on the study of units.

Commission 3: *Biology, hygiene and medicine*

Bakhmetieff's experiments with living organisms; refrigeration in anatomy, skin diseases, and in relation to food handling, ice cream bacteriology, home hygiene, molds, and serum and vaccines.

Commission 4: *Refrigerating machinery*

Kelvin-Joule effect; hydrocarbon refrigerants; compression and air machines; ethyl chloride; water jackets; condensers; water, air and brine cooling; machine standardization.

Commission 5: *Insulating materials*

Trials of insulating materials; thermal efficiency; crushing and bending resistance; experiments on conducting properties; air spaces; solid and granular insulators; new materials; refrigerator cars; testing.

Commission 6: *Refrigerating plant and testing methods*

Study of volumetric and economic efficiency and production with a view to standardization of machines; contractors' guarantees; fluid indicators; determination of power, speed, air output, temperature and humidity; fire, defrosting; testing plant.

Commission 7: *Food and perishable produce*

Food preservation and milk supply inquiries; scientific principles in food preservation; chilled and frozen meat; fish (Ottesen method), egg, fruit, bakery and confectionery refrigeration.

Commission 8: *Agricultural industries*

Refrigeration in wine treatment; vault cooling; preservation of hops, plants, flowers, grains, tobacco, silk, coffee, dairy produce, etc., by refrigeration.

Commission 9: *Ice industries*

Manufacture of various kinds of ice; hauling machinery; power for ice-making; crushed ice and artificial snow; ice-cream making.

Commission 10: *Chemical industries*

Synthetic ammonia; gas containers; volatile liquids; refrigeration in the manufacture of fats, gelatin, explosives, pharmaceutical and photographic materials; foundry work, rubber, silk and leather, etc.

Commission 11: *Very low temperature industries*

Behaviour and treatment of gases at very low temperatures, and industrial applications.

Commission 12: *Land transport*

International rules and regulations for refrigerated land transport, under the two headings, Commercial and Technical.

Commission 13: *Water transport*

Refrigerated ship construcion; methods of stowage and packing; dunnage; temperatures and humidity; pre-cooling; refrigerated barges; fish-freezing on board ship.

Commission 14: *Legislation*

International insurance of refrigerated produce; food inspection during refrigerated transport; rules for abattoirs; control and insurance of cold stores; State and municipal support for refrigerating industry.

Commission 15: *Education and propaganda*

Practical and theoretical instruction in refrigeration; qualifications for diploma, etc.; conferences, works visits, cinema propaganda, etc.

Commission 16: *Economics and statistics*

Statistics concerning refrigerating plant, transport, quantities of merchandise handled; influence of trusts and combines on national industry.

Society Affairs

The Detroit Engineering Society will hold its annual meeting on April 26.

The International Congress of Refrigerating is to be held in London June 16-21.

The Hartford Engineers' Club will have a film "How Wire Rope is Made," as the attraction for its April 28 meeting.

The St. Louis Section of the A.S.M.E. will have "Oil Engines" as the topic for its April 22 meeting. E. B. Pollister and Ray Burrus will be the speakers.

The Utah Section of the A.S.M.E. will hear the president of the American Society of Civil Engineers at its meeting with the Engineering Council on April 28.

The Colorado Section of the A.S.M.E. will hold its April 25 meeting at the Metropole Hotel, Denver. Walter F. Mallory, of the University of Colorado, will speak on "Diesel Engines."

The Minneapolis Section of the A.S.M.E. will hear John D. Harper, of Fairbanks-Morse and Co., speak on the subject of "Oil Engines" at its April 22 meeting.

The Schenectady Section of the A.S.M.E. will hear Dr. Charles Lucke speak on the "Commercial Efficiency of Oil and Steam Plants," at its April 25 meeting.

The Philadelphia Section of the A.S.M.E. will hear C. E. Richardson, of the Bethlehem Steel Co., discuss the new Bethlehem Diesel engine on April 22. A two-reel motion picture will illustrate his talk.

The Metropolitan Section of the A.S.M.E. and Student Branch will have "Combustion Control for Steam Boilers Using Stokers and Pulverized Coal," as the subject for the April 30 dinner meeting. The speakers will be R. J. S. Pigott, E. G. Bailey, M. G. Benjamin, K. L. Martin and C. H. Smoot.

The Tri-Cities Section of the A.S.M.E. will have a dinner meeting at the LeClair Hotel, Moline, on April 24. "Boiler Code Revision," will be the subject covered by S. M. Moore, of the Kewanee Boiler Co., and "Valve and Fitting Industry" by A. J. Mather, of the Walworth Manufacturing Co., of Kewanee.

The Detroit Engineering Society will hold its annual meeting on April 26 at the General Motors Bldg. John A. Russell, editor of *Michigan Manufacturer* and *Financial Record*, Harold H. Emmons, president of Board of Commerce, Dean Mortimer E. Cooley, of the University of Michigan, and Thurman Miller, editor of *Wilmington News Journal*, will be the speakers.

Personal Mention

Thomas Bowler has been made plant superintendent of the B. C. Valve Co., Ltd., Vancouver, B. C.

Samuel M. Stone has assumed active management of the Johns-Pratt Co. upon the recent retirement of Arthur W. Fox.

Coming Conventions

American Association of Engineers. C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual meeting at San Francisco, June 11-13.

American Boiler Manufacturers' Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Annual meeting at the "Homestead," Hot Springs, Va. June 9-11.

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Order of Steam Engineers. W. S. Wetzler, 753 North 44 St., Philadelphia, Pa. Annual meeting at Moose Hall, 1314 North Broad St., Philadelphia, Pa. June 2-7.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29.

American Society of Refrigerating Engineers, W. H. Ross, 35 Warren St., New York City. Annual meeting at Cleveland, Ohio, May 27-29.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

American Welding Society, Miss M. M. Kelly, 29 West 39th St., New York City. Annual meeting at New York City, April 23-25.

Electric Power Club. S. N. Clarkson, Keith Bldg., Cleveland, Ohio. Meeting at Seaview Golf Club, Absecon, N. J., May 26-29.

International Railway Fuel Association. J. B. Hutchinson, 6000 Michigan Ave., Chicago. Annual convention at Hotel Sherman, Chicago, Ill., May 26-29.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Illinois Association** at Rockford, Ill., June 4-6. L. G. Schlemm, 805½ South Ninth St., Springfield, Ill. **Indiana Associationa** at Lafayette, Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 612 Franklin St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio.

The National Board of Boiler and Pressure Vessel Inspectors, C. O. Myers, 502 Comstock Bldg., Columbus, Ohio. Annual meeting at Cleveland Hotel, Cleveland, Ohio, May 26-29.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 10-12, 1924, formerly announced June 11-14.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24. **Nebraska Section,** H. M. Davis, Banker's Life Bldg., Lincoln, Neb. Sectional meeting at Omaha, May 8-9.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Hotel Statler, Buffalo, N. Y., April 30 to May 2, 1924.

Stoker Manufacturers Association. G. A. Sacchi, Westinghouse Elec. & Manufacturing Co., Philadelphia, Pa. Annual meeting at Edgewater Beach Hotel, Chicago, Ill., June 2-4.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

William C. Rudd, formerly of Louisville, Ky., has opened an office in Cincinnati as consulting engineer and will specialize in the steam-engineering field.

Charles A. Coffin was awarded an honorary membership in the Franklin Institute, Philadelphia, in recognition of his achievements and contribution to the electrical industry recently.

William M. White, chief engineer of the hydraulic department of the Allis-Chalmers Mfg. Co., of Milwaukee, expects to attend the World Power Conference in London and the International Management Congress at Prague in July.

Prof. J. A. Needy, Purdue University, West Lafayette, Ind., gave the ninth of a series of lectures on smoke abatement before an audience in the Chamber of Commerce Building, Indianapolis, April 15, on the subject of "Boiler-Room Economy."

Edwin Jowett has recently been promoted to vice-president in charge of power plants and also a director of the Kansas City Power & Light Co. His many friends will be interested to learn that he will sail for England June 19, as a member of the American committee to attend the World Power Conference.

Business Notes

The Hisey-Wolf Machine Co., Cincinnati, Ohio—Price List No. 29, March 17, for electric drills.

The Cave Welding Co., Springfield, Mass., welders and manufacturers of boilers and gas and oil tanks, has changed its quarters from Taylor St. to 453 Worthington St.

The Kirk & Blum Manufacturing Co., Cincinnati, Ohio, announces that H. H. Valiquet, for the last eighteen years chief engineer of the B. F. Sturtevant Co., (Chicago division) has joined its organization.

The Moore Steam Turbine Corp., Wellsville, N. Y., has opened a Pittsburgh office in the Ferguson Bldg., 319 Third Ave. H. A. Schultz, formerly with the Frederick Pump Co., has been oppointed manager.

Joseph Harrington and G. R. Wolf are incorporating a sales organization to market in the Middle West territory the new stoker that Mr. Harrington has perfected recently for small power-plant boilers and domestic heating. The offices of the new company are at 650 Old Colony Bldg., Chicago, Ill.

The Combustion Engineering Corp., Broad St., New York City, announces that Charles Longenecker, formerly with the Bonnot Co. at Canton, Ohio, has become associated with the corporation and will be connected with the industrial department which will specialize in pulverized fuel.

The Clark Engineering Co., of Racine, Wis., specializing in factory equipment, announces the purchase of the Racine branch of the Badger-Packard Machinery Co., which dealt largely in shafting, pulleys and machinery. These lines will be extended and other plans for extension are under way.

The Rust Engineering Co., Pittsburgh, Pa., has moved its New York City office from 140 Liberty St. to 30 Church St.

The Mason Regulator Co., Boston, Mass., manufacturers of reduction valves, pump governors, etc., has recently appointed F. Kenneth Morrison to represent it in the traveling sales department.

The McClave-Brooks Co., Scranton, Pa., announces the appointment, effective April 24, of T. Armory Coffin, formerly chief field engineer for the Phoenixville plant of the Heine Boiler Co., as manager of its New England territory, with headquarters in Boston, at 200 Devonshire St.

The Reliance Gauge Column Co., Cleveland, Ohio, manufacturer of steam specialties, has recently opened two additional branch offices. S. I. Fink Co., 227 Second Ave., Pittsburgh, Pa., will represent the company in the Pittsburgh district, and the O. C. Keckley Co., 565 Washington Blvd., Chicago, Ill., the Chicago district.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Apr. 7, 1924	Apr. 14, 1924
Pool 1	New York...	$3.00	$3.25
Smokeless	Columbus....	2.50	2.35
Clearfield	Boston	2.50	2.50
Somerset	Boston	2.50	2.70
Kanawha	Columbus....	1.80	1.75
Hocking	Columbus....	1.75	1.75
Pittsburgh No. 8	Cleveland...	1.85	1.85
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville...	1.75	1.90
S. E. Ky.	Louisville ..	1.75	2.00
Big Seam	Birmingham	2.25	2.25

FUEL OIL

New York—April 17, light oil, tank-car lots, 28@34 deg. Baumé, 5½c. per gal., 36@40 deg. 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis—April 12, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2 per bbl.; 32@36 deg., gas oil, 5½c. per gal.; 38@40 deg., 6½c. per gal.

Pittsburgh—April 8, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 34@40 deg., fuel oil, 6c. per gal.; neutral, 9c. per gal.

Dallas—April 12, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Philadelphia—April 12, 28@30 deg., $2.31@$2.36 per bbl.; 18@22 deg., $2.10 @$2.16½; 13@16 deg., $1.68@$1.74½ per bbl.

Boston—April 7, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4⅝c. per gal., light oil, 28@32 deg. Baumé, 6⅝c. per gal.

New Plant Construction

Ala., Auburn—The Board of Trustees, Alabama Polytechnic Institute, contemplates the installation of electric-operated pumping equipment in connection with a proposed waterworks plant with capacity of 350,000 gal. per day, estimated to cost $50,000. Dr. Spright Dowell is president.

Ala., Birmingham—The Estes Lumber Co. is considering the rebuilding of the portion of its mill and boiler plant recently restroyed by fire with loss estimated at $75,000, including equipment.

Ala., Birmingham—The C. H. Grayson Lumber Co. plans for the construction of a steam-operated power house at its proposed mill on 7-acre tract of land, recently acquired, estimated to cost $150,000.

Ala., Crichton—The Mobile Paper Mills, Inc. recently organized with a capital of $200,000, plan for the construction of a steam-operated power house at its proposed local paper mill, on which work will begin at once. J. M. Walsh is president.

Ariz., Clifton—Dell M. Potter, Clifton, and associates, are developing plans for the construction of a hydro-electric power plant on the Black River to cost in excess of $350,000. Application is being made to the Federal Power Commission for permission.

Ariz., Morman Flat—The Salt River Valley Water Users' Association, Phoenix, Ariz., will install a hydro-electric generating plant on the Salt River, near Morman Flat, where a power dam is now in course of construction. It will be designed for an ultimate capacity of 35,000 hp. An appropriation of $4,000,000, has been arranged for the entire project.

Ark., Conway—The Common Council has acquired additional property in the vicinity of the steam-operated municipal power station and has tentative plans for enlargement, including additional equipment. The Light and Water Committee is in charge.

Calif., Los Angeles—The Weber Show Case & Fixture Co., 440 Seaton St., will build a boiler plant with two 100 hp. boilers and auxiliary equipment, at its new one-story works at 5714 South Park Ave., to cost about $300,000, on which work will be commenced at once. Hamm & Grant, Inc., Ferguson Bldg., is engineer.

Calif., Redlands—The Redlands Ice & Cold Storage Co. is planning for the erection of a one-story cold storage plant addition to the former local plant of Paine & Cornwall, recently acquired, estimated to cost $80,000.

Calif., Santa Barbara—Herbert Nunn, city manager, has tendered a report to the city officials recommending the construction of a municipal hydro-electric plant at Gibraltar Lake, to cost about $40,000.

Calif., Westwood (Lassen County)—The Red River Lumber Co. plans for the construction of a power house at its proposed local veneer mill, estimated to cost $500,000. J. B. Walker is president.

Conn., Norwich—The Eastern Connecticut Power Co. has tendered an offer of $734,896, for the municipal electric power plant and if acquired purposes to develop the station for central station service in this district.

D. C., Washington—The Bureau of Supplies and Accounts, Navy Department, will take bids until April 29, for two turbo-generators, and one set of spare parts for the Puget Sound, Wash., navy yard, as per schedule 2063.

Fla., St. Augustine—The St. Augustine Lumber Co., recently organized, will build a boiler plant at its new mills in the vicinity of South and Cerro Sts., on which work has been commenced. I. M. and W. A. Lockwood head the company.

Fla., Sarasota—The City Council will receive bids until April 28, for equipment for a municipal power plant, including one 750 hp. Diesel oil engine direct-connected to a 500 kw. alternator, 2,300-volt, 3-phase, 60-cycle; with belt-driven exciter, generator panel and auxiliary apparatus. Also, at the same time, alternate bids for two 500 kw. generators, with steam-driven uniflow or turbine engines, exciters and control panels; two surface condensers; two water-tube boilers; boiler feed pumps; open-type water heater; water softener for boiler feed water; radial brick stack, and 10,000 gal. fuel oil tank. H. I. Southwick is city clerk.

Ga., Columbus—The City Water Board, W. J. Wood, chairman, plans for the installation of electric-operated pumping equipment in connection with proposed extensions and improvements in the municipal waterworks, for which a fund of $250,000 is being arranged for a 36-months period.

Ga., Dawson—The City Council is considering the installation of electric-operated pumping equipment in connection with a proposed new waterworks system, estimated to cost $35,000.

Ga., Fortson—The King Lumber Co. plans for the construction of a steam power plant at its proposed lumber and planing mill on tract of land recently acquired, estimated to cost $80,000.

Ga., Savannah—The Chapin-Sacks Corp. is planning for the installation of a cold storage plant in a portion of its three-story building, estimated to cost $75,000.

Greece, Athens—The Minister of Communications is taking bids until July 1, for pumping machinery, electric power equipment, etc., for a waterworks on the Charadros River, near Marathon, for Athens, Piraeus and vicinity, as per plans and information on file at the district offices of the Bureau of Foreign and Domestic Commerce, 734 Customhouse, New York; 1801 Customhouse, Boston, Mass.; and 930 Witherspoon Building, Philadelphia, Pa.

Hawaii, Kekaha—The Hawaii Commercial & Sugar Co. plans for the construction of a hydro-electric power plant in the vicinity of its mill at Kekaha, Island of Maui, with initial output of 5,000 kw.

Idaho, Moscow—Bonds have been voted for $40,000 for extensions in the municipal waterworks, to include the installation of electric-operated pumping equipment.

Ind., Columbus—The Morgan-Everitt Co., Columbus, contemplates the construction of a steam power plant at its proposed vegetable canning factory, estimated to cost $95,000. The local Chamber of Commerce is interested in the project.

Ind., Richmond—The Interstate Public Service Co., Indianapolis, has negotiations in progress for the purchase of the local municipal electric light and power plant for a consideration stated at $1,500,000. The utility is said to be planning to develop the plant for central station service in this section.

Iowa, Eagle Grove—The Northern Iowa Gas & Electric Co. plans for the construction of an addition to its local steam-operated electric generating plant, including additional equipment.

Iowa, Fairfield—The Iowa Electric Co., Cedar Rapids, will begin work in June on the proposed extensions and improvements in its local steam-operated power plant, estimated to cost in excess of $200,000, including equipment.

Kan., Bonner Springs—A. G. Parker, city clerk, will receive bids until April 25 for an addition to the pumping plant at the municipal waterworks, with suction and discharge lines, etc. The Burns & McDonnell Engineering Co., Interstate Bldg., Kansas City, Mo., is engineer.

Kan., Caney—The Connelly Glass Co. is said to be planning for the construction of a steam-operated power plant in connection with the proposed rebuilding of the portion of its local works recently destroyed by fire with loss estimated at $300,000.

Ky., Ashland—The Carter County Clay Co., Kitchen Building, E. M. Evington, secretary, plans for the construction of a power house at its proposed brick manufacturing plant in the Mount Savage section, estimated to cost about $225,000.

Ky., Falmouth—The Northern Kentucky Power Co., Frankfort, Ky., has tentative plans for the construction of a hydro-electric power plant on the Licking River. Application has been made for permission to construct a dam.

Ky., Shelbyville — The International Planters Corp., J. M. Sturgeon, Jr., in charge, plans for the early rebuilding of the boiler house at its redrying plant, recently destroyed by fire.

La., Baton Rouge—The Oliver H. Van Horn Co., Inc., New Orleans, La., contemplates the construction of a boiler house at its proposed local shipyard, for which a site is being selected, estimated to cost about $90,000.

La., Lafayette—At a special election, citizens have approved a bond issue of $200,000, for extensions and improvements including considerable additional equipment in the municipal electric power plant and waterworks system. Plans will be prepared at an early date.

La., New Orleans—The Board of Port Commissioners plans for the installation of mechanical coal-handling equipment in connection with proposed improvements in the municipal port property, for which an appropriation of $3,000,000, is being arranged.

La., Oak Grove—The Common Council has authorized plans for the construction of a municipal electric power plant, steam-operated, and a waterworks system. Henry A. Mentz, Magnolia, Miss., is engineer.

Md., Baltimore—The Consolidated Gas, Electric Light & Power Co., Lexington Bldg., has plans under consideration for extensions and improvements in its steam-operated electric plant on Gould St. to cost in excess of $1,000,000, with equipment.

Md., Middletown—The Common Council plans for the installation of electric-operated pumping equipment in connection with a proposed municipal waterworks. A bond issue will be arranged.

Md., Oakland—The Youghiogheny Hydro-Electric Corp., affiliated with the Pennsylvania Electric Corp., Johnstown, Pa., has obtained permission to issue bonds and stock in an amount of $7,500,000, a portion of the fund to be used in connection with its proposed hydro-electric generating plants on the Youghiogheny River, on which preliminary work is in progress.

Mass., Boston—Plans are being completed for the installation of a steam-operated power station in the proposed fourteen-story hotel to be erected at Columbus Ave. and Arlington St., Park Square section, by the Statler Hotel Co., Buffalo, N. Y., J. W. Rittenhouse, in charge. It will cost approximately $14,000,000. Bids are being asked on a general contract. Tenney & Ohmes, 101 Park Ave., New York, are steam engineers. Meyer, Strong & Jones, Inc., same address, are electrical engineers; George B. Post & Sons, same address, are architects.

Mass., West Newbury—The Town Council has appointed a special committee to perfect plans for the construction of a municipal electric light and power plant, steam-operated, to cost approximately $25,000. John D. King is chairman.

Mich., Lansing—The Lansing Fuel & Gas Co. plans for the installation of a battery of eight boilers and accessory equipment in connection with extensions in its local plant.

Mich., Port Huron—The Dunn Sulphite & Paper Co., 57 East Philadelphia Ave., Detroit, will soon commence foundations for its proposed paper mill at St. Clair and River Sts., with steam-operated power house, estimated to cost $500,000. A general building contract has been awarded to the O. F. Miller Co., Pratt Bldg., Kalamazoo, Mich. Billingham & Cobb, Press Bldg., Kalamazoo, are architects and engineers. T. Dunn is president.

Mich., Royal Oak—R. B. Fleming, city clerk, will take bids until May 19, for the installation of a pumping plant for the sewerage system, with disposal plant, for a capacity of 2 m.g.d. Hoad, Decker, Shoecraft & Drury, Ann Arbor, Mich., are engineers.

Mich., Ypsilanti—The Ford Motor Co., Highland Park, Detroit, has acquired local property heretofore held by the city, including rights to construct a power dam on the Port Huron River for proposed hydro-electric development.

Minn., Faribault—The Common Council is considering plans for the construction of a municipal electric light and power plant, expecting to commence work early in the fall.

Minn., St. Paul—The Board of Trustees, Macalester College, will soon take bids for the construction of a power house at the institution. William M. Ingeman, 637 Endicott Bldg., is architect.

Minn., Winona—The Winona Light & Power Co. has issued a call for bids on general contract for the construction of a one-story addition to its steam-operated power plant, 56 x 74 ft., estimated to cost $150,000, including equipment. Mead & Seastone, Journal Bldg., Madison, Wis., are engineers.

Miss., Fayette—The Common Council is considering plans for enlargements in the municipal electric power plant, to include the installation of a 100 hp. engine-generator unit and accessory equipment.

Mo., Cameron—The Common Council has rejected all bids recently received for extensions and improvements in the sewerage system, and the installation of two electric-operated sewerage pumping stations, and purposes to call for new bids in the near future. The project is estimated to cost $250,000. Black & Veatch, Mutual Bldg., Kansas City, Mo., are consulting engineers.

Mo., Columbia—The City Council has tentative plans under consideration for the construction of a municipal ice-manufacturing plant. It is proposed to vote bonds at an early date.

Mo., St. Joseph — The Conser Laundry Co., 908 St. Francis St., plans for the construction of a steam-operated power house at its proposed new mechanical laundry at Seventeenth and Buchanan Sts., to cost about $165,000 including equipment.

Mo., St. Louis—The Christian Hospital Association, Grand and Palm Sts., Dr. C. A. Mellies, chairman of building committee, will build a central power house for lighting and heating service at its proposed hospital at Newstead and Taylor Aves., estimated to cost $360,000. Bids will be asked in from 60 to 90 days. Hoener, Baum & Froese, Grand Boulevard and LaClede Ave., are architects.

Mont., Hardin—Bonds for $25,000 have been voted for extension in the local steam-operated power plant and system. The city clerk is in charge.

Neb., Fairbury—The Common Council has rejected all bids recently received for the construction of the proposed addition, including boiler house, at the municipal light and water plant, and will take new bids in the near future. Henry W. Fouts is city clerk.

Neb., St. Paul—The Common Council contemplates the installation of electric-operated pumping equipment in connection with extensions in the municipal waterworks. L. H. Bell is city clerk.

N. H., Manchester — The Manchester Traction, Light & Power Co. has authorized extensions, improvements and additional equipment in its hydro-electric power plants at Kelly's Falls, Piscataquog River, and Garvin's Falls, Merrimack River. Stone & Webster, Inc., 147 Milk St., Boston, Mass., is engineer.

N. J., Summit—The Jersey Central Power & Light Corp. has arranged for a sale of preferred stock totaling $1,250,000, a portion of the proceeds to be used for the acquisition of additional properties and the completion of a steam-operated electric power plant now in progress, to be equipped for a capacity of 16,000 hp. T. R. Crumley is vice-president.

N. Y., Fort Edward—The Standard Paper Co. is reported to have plans under consideration for the construction of a steam-operated electric power plant for service at its mill, estimated to cost about $85,000.

N. Y., New York — The International Petroleum Co., 120 Broadway, is reported to be planning for the construction of a number of pumping plants in connection with a proposed pipe line in the Magdalena River section, Colombia, S. A., for oil transportation from interior to the coast.

New Zealand, Wellington — The Public Works Department will receive bids until July 1, for two pipe lines, each 2,575 ft. long for the Lake Coleridge hydro-electric power station, with 351 ft. tunnel lining pipes, with fastenings, fittings, etc., as per specifications on file.

N. C., High Point—The Knox Upholstering Co., 300 High St., will build a boiler plant at its proposed new factory, for which a general construction contract has been awarded to J. L. Crouse, Greensboro, N. C. Orders for equipment will be placed at an early date.

N. C., High Point—The Knox Upholstering Co., 300 High St., will build a one-story steam power house, 30 x 42 ft., at its proposed local mill, estimated to cost close to $75,000.

N. D., Burlington—James Johnson plans for the installation of a pumping plant, using rotary units, in connection with a local irrigation system.

N. D., Grand Forks—Bonds for $110,000 have been approved by a vote of citizens, the fund to be used for a municipal electric power plant. Plans will be drawn and bids asked at an early date. Charles M. Evanson is city clerk.

Okla., Stillwater—The City Council has called a special election on April 24 to vote bonds for $250,000, for extensions and improvements in the municipal waterworks, to include the installation of electric-operated pumping equipment. V. V. Long & Co., Oklahoma City, Okla., are engineers.

Ore., Astoria — The Standard Oil Co. plans for the installation of a pumping plant in connection with its proposed distributing works near Pier 3, estimated to cost $100,000.

Ore., Roseburg—Stanley W. Taylor, and associates, have made application to the state water board for permission to construct and operate a hydro-electric power plant on the South Umpqua River.

Pa., Allentown—The Pennsylvania Power & Light Co. will proceed with plans for its proposed hydro-electric generating plant on site purchased, with capacity of 40,000 kw., to be completed during the coming year.

Pa., Johnstown—The Penn Public Service Co. is arranging a fund of $45,000,000, for extensions, improvements, etc., to include the completion of three hydro-electric power plants on the Clarion River, known as the Piney Development, now in progress, estimated to cost $18,000,000, with power lines, etc. F. T. Hepburn is president.

Pa., Lewistown—The Pennsylvania Wire Glass Co., Pennsylvania Bldg., Philadelphia, Pa., has authorized revised plans for its proposed local plant, 185 x 750 ft., to include a steam-operated power house. The project will involve about $475,000. New bids will soon be asked. Walter Cox is president; F. A. Hayes is company engineer.

Pa., Philadelphia—The H. O. Wilbur & Sons Co., 233-35 North Third St., has filed plans for the erection of a one-story boiler plant at its chocolate factory. The general building contract has been awarded to the Turner Construction Co., 1713 Sansom St.

Pa., Philadelphia—John Bromley & Sons, Inc., Lehigh Ave. and A St., has filed plans for extensions and improvements in the boiler plant at its textile mill.

Pa., Philadelphia — The Quaker Industrial Alcohol Co., Bartram Ave. and Eighty-second St., has filed plans for the erection of a one-story boiler house at its plant, and will proceed with work at once.

Pa., Pittsburgh — The Transcontinental Oil Co., Bendum Trees Bldg., plans for the construction of a steam power plant at its proposed new oil refining plant in Northern Colorado, estimated to cost in excess of $800,000. The project will be carried out by the Transcontinental Oil Co. of Colorado, a recently organized subsidiary. T. R. Cowell is secretary.

S. C., Belton—The Blair Mills, Inc., will install a steam-operated electric power station for service at its new cotton mill addition, on which work has been commenced. E. B. Rice is president.

Tenn., Chattanooga — The Stone Fort Land Co. has inquiries out for pumping equipment for water pressure service, etc., in its proposed eleven-story addition to the Hotel Patten. Other power equipment will also be installed.

Tenn., Columbia — The Southern Cities Power Co., Chattanooga, Tenn., plans for an addition to its hydro-electric power plant on the Duck River, near Columbia, to increase the capacity 1,000 hp.

Va., Grundy—The Board of Directors, Mountain Industrial Institute, has authorized plans for the construction of a central steam plant for heating and general power service at the institutional buildings, in connection with other new structures, to cost about $200,000. Mahood & Van Dusen, Bluefield, W. Va., are architects.

Va., Hampton Roads—The local supply officer, Navy Department, will take bids at once for 6 recording thermometers, as specified in Y. & D. requisition 75, for the local naval operating base.

Wash., New Dungenes—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will take bids until May 1, for the construction of a power plant at the local naval station, as per specification 4938.

Wash., Tacoma—Ira S. Davidson, commissioner of light and water, is arranging an immediate call for bids for machinery and equipment for the No. 2 unit for the municipal power development on Lake Cushman. Figures on the No. 1 station were asked recently. J. L. Stannard is chief engineer for the project.